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# THE JOURNAL
## OF
# THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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## ROYAL ASTRONOMICAL SOCIETY

## OF CANADA

VOL. VI. MARCH-APRIL, 1912. No. 2


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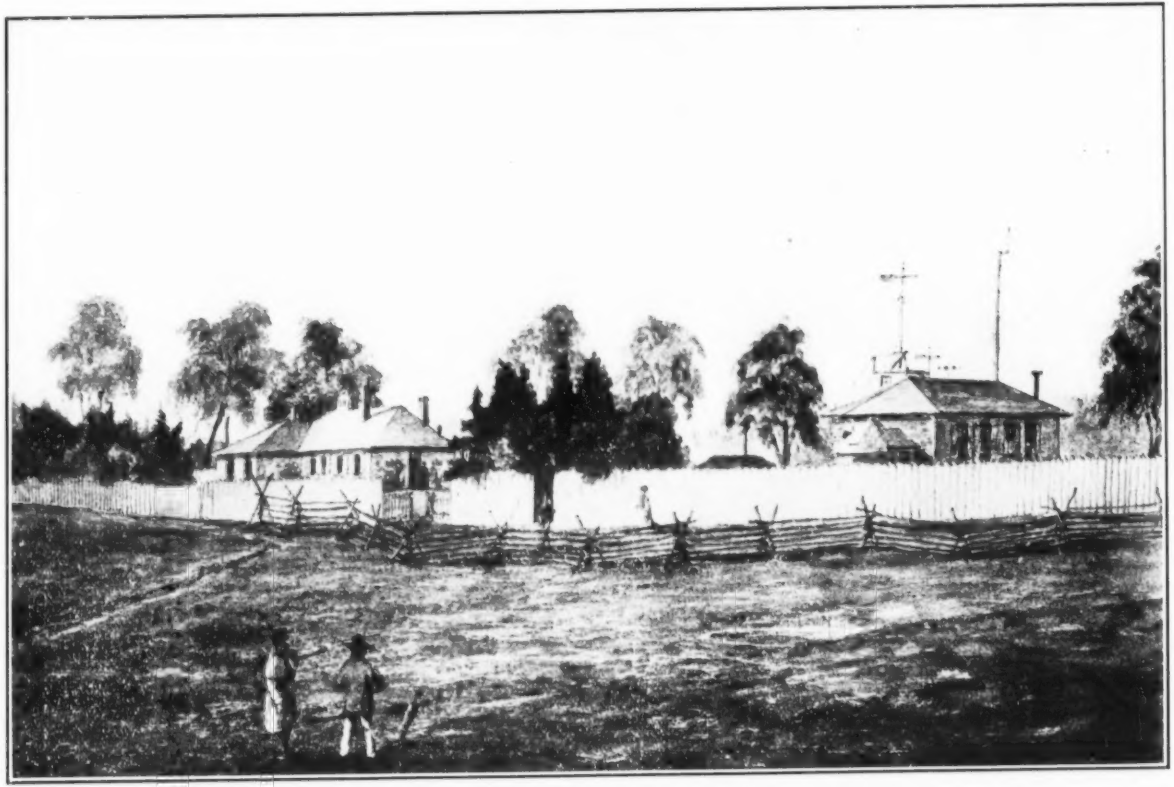

METEOROLOGICAL AND MAGNETIC OBSERVATORY, TORONTO

The log building on the right was erected in 1840 by Lieut. C. J. B. Riddell, R.A., F.R.S., who was Director of the Observatory until February, 1841. The building on the left was used as the Director's residence. It is still standing

(From a water-color painted in 1852 by Wm. Armstrong).

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OF CANADA

VOL. VI. MARCH APRIL, 1912. No. 2

# METEOROLOGY IN CANADA

BY R. F. STUPART
DIRECTOR OF THE DOMINION METEOROLOGICAL SERVICE

IT has been found that Meteorology in Canada is so closely identified with the Meteorological Service that a discussion of the one is practically a history of the growth and development of the other, and the writer has, therefore, decided that a brief *résumé* of the work of the Service will best indicate the progress of meteorological research in the Dominion.

It is quite true that there have been many persons outside the Service who have been observers of weather changes and who have from time to time made public their opinions regarding the character of seasons, yet it is doubtful whether any one of them really grasped the truth that atmospheric phenomena observed locally, were intimately connected with the general circulation of the atmosphere over the whole globe.

In order to gather information as to whether any attention was paid to Meteorology and Climatology in the very early days days of Canadian History, the "Relations of the Jesuits" have been carefully gone over, and all references to climatic phenomena have been copied and arranged under various headings, such as winter, summer, drought and other phenomena and from these notes it has been possible to draw conclusions as to the general character of the seasons in Canada during the 17th and 18th centuries. Instrumental records being, however, entirely

wanting, no very accurate comparison can be made between the climate of Canada during the early days of the French settlement and the present time ; and a study of the notes leads to the conclusion that the only valuable information to be gathered from this source is that the climate then was just about the same as it is now.

It would appear that some of the earliest instrumental meteorological records made in Canada were by Mr. Thomas Hutchins, an officer of the Hudson's Bay Company, at York Factory and Severn House in 1772-1773, and it is believed that there are several other records by Hudson's Bay men in the archives of the Royal Society in London.

Delving into old provincial records has further shown that during the early part of the 19th Century, there were a few individuals in Ontario, Quebec and the Maritime Provinces, who for shorter or longer periods have kept meteorological records and, doubtless, it would be quite possible to bring all these records together and publish them ; but owing to their fragmentary character, it is unlikely that they would prove of any great value. Perhaps the most indefatigable among observers prior to 1840 was the Rev. Mr. Dade, who has bequeathed us a record extending over many years.

It was not, however, until the British Government established a Magnetical and Meteorological Observatory in Toronto that meteorological observations were begun on a basis which promised continuity and scientific precision. The first observatory building was erected under the direction of Lieutenant Riddell, R.A. It was of logs, rough cast on the outside and plastered on the inside and was completed during the summer of 1840, observations both magnetical and meteorological being begun in September of that year. Lieutenant Riddell returned to England in the spring of 1841, and Captain, afterwards General Sir Henry Lefroy, who had meanwhile established an observatory of a similar character in St. Helena, was transferred to Toronto, in order that he might undertake a magnetic survey of British North America. Captain Lefroy remained as director of the

observatory until in the spring of 1853 it ceased as an Imperial establishment.

The Observatory having been taken over by the Provincial Government, arrangements were made for retaining the military observers, and the institution was placed under the direction of Professor Cherriman, the Professor of Mathematics and Natural Philosophy in University College, who continued in charge for two years. During this period a stone observatory was erected on the exact site of the old frame building, the pillars on which the magnetic instruments were placed being left standing and the walls built around them. Presumably there was no change in the position of the meteorological instruments.

Professor G. T. Kingston, M.A., (Cantab) was appointed Director of the Observatory in 1855. For about ten years, he apparently confined his attention almost exclusively to magnetic work and the local meteorology, but it is quite obvious from correspondence and the various reports made by him to the Government that for some years prior to 1870 he had been considering the possibility of inaugurating a Meteorological Service in Canada along much the same lines as those then existing in Great Britain and the United States. It was not, however, until 1869 that any definite move was made. He then addressed himself by letter and circular to persons actually engaged in meteorology, including the Principals of several Grammar Schools in Ontario, who for several years had acted as observers, and others who, it was thought, would favor this movement, and requested their co-operation. The result was a steady increase in the number of observers, who now with unity of purpose and action made systematic and similar observations in different portions of the Dominion.

From October 1869 to the spring of 1871, the meteorological work in Canada was carried on by an exclusively voluntary organisation; no emoluments whatever were attached to the services of the observers, and the instruments were provided from private sources or lent from the Magnetic Observatory, Toronto, from which establishment forms for registration were also fur-

nished. The work connected with organising new stations and of discussing and compiling returns were also gratuitously performed by the Director and Assistants of the Observatory. Professor Kingston received much assistance from a few persons in the various provinces who recognised the usefulness of the proposed work. Among others, were the late Archbishop Machray, of Rupert's Land ; the late F. Allison, M.A., of Halifax ; the late H. J. Cundall, C.E., of Prince Edward Island ; and Captain Ashe, R.N., of Quebec. In more recent years E. Baynes Reed, Esq., now Chief Meteorological Agent in British Columbia, has proved a most valuable officer of the Service.

In the spring ot 1871, a grant of $5,000 having been made by the Federal Government for the promotion of meteorological research, considerable impetus was given to the movement.

With funds at his disposal Professor Kingston at once opened a correspondence with the Chief Signal Officer at Washington, offering to procure the transmission of weather intelligence from stations in the various provinces in exchange for some to be sent to Canada by that Officer, and soon it was agreed that reports from Port Stanley, Port Dover, Southampton, Toronto, Kingston and Quebec should be sent to Washington and that in return 15 United States stations should be sent to Toronto.

About this time Professor Kingston obtained the services of Mr. Charles Carpmael, M.A., Fellow of St. John's College, Cambridge, who was appointed Deputy Superintendent of the Service.

The preparation of a daily synchronous weather chart was begun early in 1873, but the information received in Toronto was quite inadequate to admit of daily forecasts and the issue of storm warnings. However, through the courtesy and goodwill of the Chief Signal Officer at Washington, warnings of expected storms in Canada were sent to Professor Kingston at Toronto and forwarded by him to such places as he deemed advisable.

By 1876 there were 15 stations reporting three times daily to Toronto as follows :— Sydney (N.S.), Halifax (N.S.), Chatham (N.B.), and Father Point, Quebec, Montreal, Ottawa,

The Second Building, erected on the site of the first, in 1855. The dome was added in 1882.

Kingston, Port Dover, Port Stanley, Saugeen, Rockliffe, Parry Sound and Winnipeg. The storm signal display stations numbered 37, and observing stations, including all classes, numbered 115. Forecasts were first issued during the summer of this year, a chart of the weather with probabilities for the ensuing 24 hours being prepared each morning at 10 o'clock and furnished to the Marine Exchange Board in Toronto for public inspection. After September 1st warnings were first issued from the Central Office without waiting for advice from Washington and in October the daily forecasts were first printed in the Toronto evening papers. In December the forecasts were furnished to the Telegraph Companies and forwarded by them for publication in the various papers in Ontario and in Montreal. The *Monthly Weather Review* was first published for January, 1877. The first nine numbers were on two pages of foolscap paper and were lithographed. In November it was printed and the size doubled.

Professor Kingston resigned office on January 31st, 1880, leaving the Service a thoroughly organised system, a credit alike to the country and to himself. The total number of observing stations at this time was 162, and of these 18 reported by telegraph to Toronto. There were 37 storm signal display stations, 21 of which were on tidal water and 16 on the Great Lakes.

Mr. Charles Carpmael was now appointed Director of the Service, and a little later Lieut. A. R. Gordon, R.N., was appointed Deputy Superintendent. Steady progress continued in the development of the Service, and, perhaps, one of the most important improvements was the arrangement whereby every telegraph office in the country should receive the daily forecasts which were issued each evening for the following day and night. So satisfactory did this prove, that for many years the morning forecasts were practically dropped and the only bulletin issued in the forenoon was that for the Toronto Board of Trade. Both Professor Carpmael and Lieut. Gordon were zealous in their work of increasing the efficiency of the Service and in adding to the number of storm signal display stations.

A great improvement was made in the early eighties, by the

extension of the *réseau* of telegraph reporting stations in the Northwest Territories, this being concurrent with the extension of the telegraph beyond Winnipeg and the opening of the Canadian Pacific Railway.

In 1884, when the Government determined to send out an expedition to Hudson's Straits and Bay to report on the navigability of those waters, Mr. Gordon was asked to take charge of the expedition, and the various stations which were established temporarily along those northern shores were equipped and organised by the Service, and the chief observer was an officer from the Central Office, Toronto. The climatic data obtained during two years was, of course, indispensable for the purposes of the expedition and have proved of great value from general climatological considerations.

In 1890 a chief station was opened at Victoria, B.C., and about this time telegraphic reports were first received from Bermuda. The wisdom of the establishment of this latter station has been amply proved on innumerable occasions since, as indications of storms developing near the American Coast and of West India hurricanes, are oftimes first apparent from the Bermuda reports.

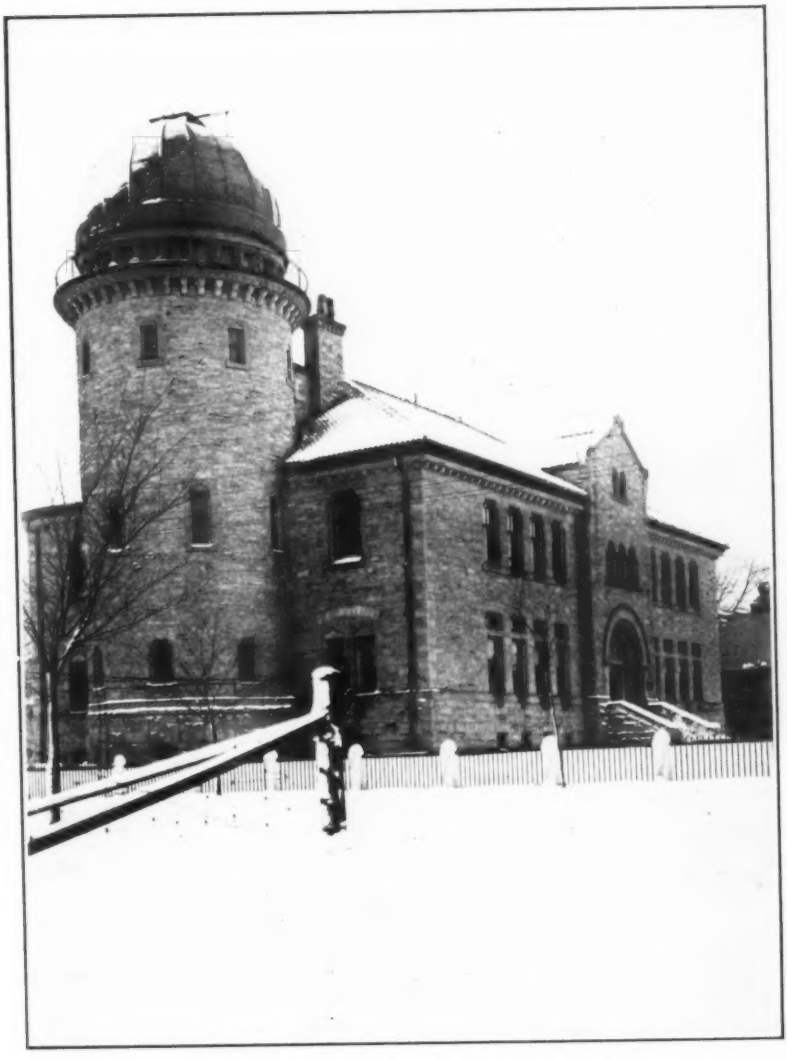
Lieutenant Gordon died in 1891 and Professor Carpmael, after an illness of over a year, died in England, in October, 1894. At the close of 1894 there were 31 telegraph reporting stations and 45 storm signal display stations.

The present Director of the Service, after acting for nearly a year, was appointed Director of the Meteorological Service of Canada and the Magnetic Observatory, by Order in Council, dated 28th December, 1894.

For January, 1895, was first published a *Monthly Weather Map*, which was issued on February 6th, and has been continued monthly ever since. It has proved of much value to the Service as a means of retaining the interest of the voluntary observers and also to the grain buyers and those interested in agriculture.

In the autumn of 1894 a bulletin designed especially in the interests of the shipping, both of the Atlantic ports and the

PLATE VI.



The present Headquarters of the Service, erected 1909.

Great Lakes, was first issued each morning, giving a forecast for the current and following day. By arrangement with the various telegraph companies this was transmitted promptly to harbor masters who agreed to post the bulletins in some conspicuous place where they might be seen by vessel men. At this time the 10 a.m. issue of the forecasts was again published in the evening papers at most important places.

Prior to 1895 the *Annual Climatological Report* was an octavo volume of about 300 pages, containing fairly complete tabular information regarding the temperature and precipitation of the Dominion, but omitting all other climatological factors. In the year just named, however, the form of the *Report* was changed to a quarto volume and the general arrangement was brought into harmony with that agreed upon by the International Meteorological Committee.

In the earlier days of the Service, stations had been established at Churchill, York Factory and Moose Factory, and others were now started at Norway House and Haileybury, Ont., it being felt that it was a matter of importance to obtain meteorological data from the more northern portions of the provinces.

In the summer of this same year, the morning daily Weather Map was first manifolded by means of stencil and typewriter for the benefit of those interested in the study of meteorology. This daily map has since undergone many changes, the most recent of which has necessitated the installation of a printing press whereby the number of copies issued has been increased to some 250 and the appearance of the chart has been greatly improved.

The map has proved, not only of interest to a small percentage of the public but in addition, of great educational worth, as to-day it is unusual to find school teachers in Ontario who have not a rudimentary knowledge of meteorology, and this is largely due to frequent inspection of the weather maps.

In 1896 the Director attended a Congress, held in Paris, of the Directors of Meteorological Institutes and Observatories, and

took part in the discussions relative to the co-ordination of results obtained in the various parts of the world.

In 1897 the Meteorological Service made the first move towards seismological research in Canada by placing a Milne Seismograph in Toronto and another in Victoria, B.C., and ever since thoroughly reliable and continuous records have been duly forwarded to the various centres of seismological research. Up to the present time, however, it has not been considered expedient to organise a branch devoted exclusively to the study of seismology, but some special work has been carried on during twelve years by an officer of the Service in Victoria, and it is probable that his results will prove very valuable and that in the future the subject will receive more attention than it has in the past.

It became necessary in 1898 to remove the magnetic instruments from the old observatory to a site distant from the electric tramways in Toronto, but the Central Meteorological Office was not removed and the exposure of the meteorological instruments remained unchanged.

In March, 1907, however, owing to the expansion of the University of Toronto it was decided to remove the Meteorological Office, and this was done to temporary quarters which were occupied for two years pending the erection of a new Meteorological Building on a site distant about one quarter of a mile from the old observatory. The new premises were occupied in September, 1909, and with adequate accommodation it became possible to augment the work of the Service along lines which had long been deemed desirable, but impossible owing to lack of room in which to place the necessary equipment. In designing the new building ample provision was made for a larger staff, together with good library accommodation and also for a laboratory to be used in connection with research work in atmospheric physics.

Following the initiative of the Meteorological Bureaus of other countries and particularly of the United States the synoptic weather map was, at the earliest inception of the Service, adopted

CAPT. J. H. (afterwards SIR HENRY) LEFROY,
Second Director of the Meteorological and Magnetic Observatory at Toronto.
(From a painting in the Canadian Institute, Toronto).

JOHN BRADFORD CHERRIMAN, (1826-1908)
Professor of Mathematics and Natural Philosophy in the University of Toronto; and Director of the Observatory 1853-5
(From a photograph, 1901).

as the basis of weather forecasts, and as we have already seen, every effort has been made to broaden the field from which observations are obtained and also to improve the character of the data supplied by observers.

The maps, however, valuable as they are, are deficient in many respects. The telegraph does not yet reach much beyond the southern margin of Canada, and the weather map shows a vast blank to the northward, and cloud observations showing the motion of the upper air are fragmentary and unreliable.

Forecasts based on such imperfect information must necessarily be liable to occasional error and as they represent the judgment of an individual, long experience combined with a special aptitude for the work, can alone lead to successful results.

Most careful attention has been given to the development of the forecasting branch of the Central Office. Those attached to it have been encouraged to persevere in their investigations of phenomena attending the development of storms and the movements of cyclones and anti-cyclones, as indicated by the maps, and further to apply as far as possible the laws of physics to the solution of the difficult problems which confront them. Mr. B. C. Webber, the Assistant Director of the Service, has carefully charted and studied every cyclonic area which has passed across the continent since 1872, and has also paid particular attention to wind movements. The zeal and the ceaseless assiduity with which this officer had studied weather changes, has contributed very largely to the success of the Canadian forecast work.

It is duly recognised that a better knowledge of the dynamics of the high area and of the low area is essential to progress, and special research in atmospheric physical work is being carried on. This includes the exploration of the upper atmosphere by means of kite and sounding balloon, taking self-recording instruments to high altitudes, and investigation in atmospheric electricity, solar radiation and other phenomena in which there is any prospect of valuable data being found.

During the past year balloons carrying the Dines Meteorograph have been sent off with regularity on days arranged for

by an International Committee and of 21 sent up 12 have been returned to the Central Office, with good records. The heights reached have varied from 11·2 to 23·2 kilometres. The isothermal layer has been found at an average height of 12·6, ranging from 16 kilometres on November 8th to 9·5 kilometres on December 7th last. The lowest temperature recorded was −70° C. at 15 kilometres on July 5th last, and the highest altitude reached was 23·2 kilometres on September 9th, when the lowest temperature recorded was 55·5° at 14 kilometres.

A kite station was established at Agincourt early last year and observations of pressure, temperature, humidity and wind direction in the free air have since been obtained with fair regularity. The highest ascent yet reached was 7900 feet above sea level on the 28th of June, 1911.

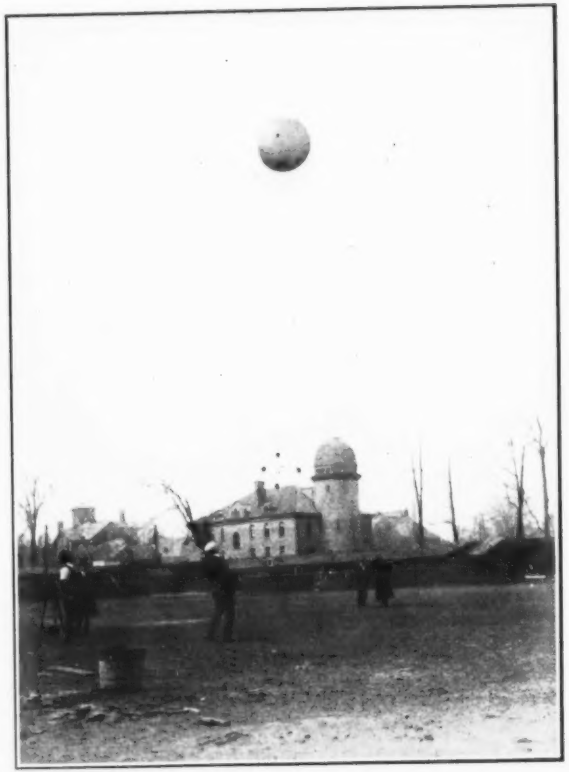
In the spring of 1910, by arrangement with the Newfoundland Government, the Canadian Service began the issue of forecasts and storm warnings to Newfoundland and ever since then the weather bulletins have been published with the same regularity in the Island Colony as in the Canadian Provinces. Newfoundland has taken over the maintenance of her various meteorological stations which were hitherto maintained by Canada, and has opened others which will be of decided benefit to international meteorology.

Very recently a most promising development of the daily weather map has been made possible by obtaining, through the courteous co-operation of the United States Weather Bureau, a certain number of foreign reports as follows:— Iceland, Faroe Islands, London, Stornaway, Malin Head, Blacksod Bay, Shetland Islands, Cuxhaven, Vladivostock, Shanghai, Lisbon, Azores, Turks Island, Havana, Honolulu and Manila, together with several United States stations in Alaska, including Unalaska; also twelve stations in Russia and Siberia and one in Japan. These reports are received in Toronto about 10 a.m. and together with the reports of this continent are entered on a map of polar projection and show with fair certainty the distribution of pressure

PROFESSOR GEORGE TEMPLEMAN KINGSTON,
(1816–1886).
Director, 1855–1880.

CHARLES CARPMAEL, (1846–1894).
Director, 1880–1894.

Preparing a balloon for a flight in the upper atmosphere. The recording instrument is the cylinder at the centre of the circle in the foreground, the spheres attached to it being to prevent a too rapid descent.



The balloon about 5 seconds after being set free

over the northern hemisphere. There is strong evidence that this new departure will be of incalculable value in forecasting.

It is expected that before long the Canadian and Newfoundland reports will be cabled to England and will, we trust, be of decided use to the British Meteorological Office.

About four years ago on the initiative of the Royal Society of Canada, invitations were issued by the Dominion Government to the Governments of the various Colonies and Dependencies of the British Empire to send representatives to take part in the meeting for the discussion of meteorological questions depending upon the co-operation of observers in various parts of the world.

The meeting was suggested at the International Conference at Innsbruck, in 1905, at which Sir J. Eliot was present as Secretary of the Solar Commission appointed by the International Meteorological Committee to promote the disscussion of the relation between solar and terrestrial changes. Sir John, who had recently retired from the direction of the Meteorological Service of India, had set forth, in his address to Section A. of the British Association at Cambridge in 1904, various important reasons for dealing with meteorological questions on a larger geographical scale than that which is possible for any individual state, and it was largely for the purpose of finding an opportunity for the discussion of such questions by meteorologists from various parts of the Empire that the meeting was suggested.

The death of Sir J. Eliot and the inability of a number of the important Colonial Governments to send representatives, made it necessary to postpone the meeting. No further official invitations were issued, but advantage was taken of the meeting of the British Association at Winnipeg in September, 1909, to assemble the representative meteorologists who were present at the meeting.

It appeared to the meeting that very considerable service might be rendered to the science of meteorology, especially in regard to the study of such questions as those indicated, if arrangements could be made for placing upon a systematic basis the exchange of data between the different meteorological organisa-

tions of the British Possessions and with that object in view the following resolution was passed :—

" It is desirable to arrange for the exchange, on an organised basis, of meteorological data between the different portions of the British Empire."

A small committee was appointed to consider the details of the proposal. The Committee met at the Meteorological Office, Toronto, on September 21st, 22nd and 23rd and formulated a scheme, subsequently offered for the consideration of the meteorologists of the various portions of the Empire.

This movement, which at one time seemed likely to be abortive, has recently given evidence of progress and there are good grounds for belief that it will greatly assist in the development of world meteorology.

Canada continues to make progress towards being in a position to fulfil her obligation to international meteorology by equipping observing stations in the northland. Dawson City became a telegraph reporting station in 1901, and within the past few years stations have been opened at Ft. Dunvegan, Ft. Vermilion, Ft. MacMurray, Ft. Chipewyan, Ft. Smith, Ft. Simpson, Ft. Norman, Ft. Good Hope, Ft. McPherson and Herschell Island, forming a chain extending from Northern Alberta to the Arctic Sea. The result so far achieved has been satisfactory, and whenever the mails are received from the North, it is possible to extend the isobars of the past months into high latitudes. It is hoped that in the not distant future a system of wireless stations will be placed in the far North, as reports from such stations will afford most valuable data for the preparation of weather forecasts. This matter has already been brought to the attention of the Government.

At the present time there are in the Dominion 543 stations at which observations are taken and bi-daily telegraphic reports are received at the Central Office from 41 of these stations. There are 110 storm signal stations ; 78 on tidal water and 32 on the Great Lakes.

The percentage of verification of forecasts for the past year

THE FORECASTING ROOM

THE OLD OBSERVATORY AT ST. HELENA,
Established by Sir Henry Lefroy in 1840.

was 86·1 and of storm warnings 91·7. As indicated by the percentage of verification, the forecasts of the Canadian Service are distinctly good and compare most favorably with forecasts issued in other countries. But a still more certain proof of their value is shown by the close attention paid to storm warnings by mariners and fishermen and by the fact that shippers of perishable goods consult the forecasts before shipping. Another clear indication that the forecasts are highly valued by those deeply interested in weather changes is found in the confidence with which the pilots of unseaworthy craft, such as dredges and barges at all times of the year, and of all vessels during the late autumn, allow themselves to be guided from port to port by the Meteorological Official.

It is gratifying to be able to state that *Meteorology* is now a recognised subject for study in the School System of Ontario and the daily map, published in the Central Meteorological Office, is distributed to colleges and schools in Toronto and various other places.

One, even to-day, does occasionally hear disparaging remarks regarding the accuracy of the forecasts, and mistakes do occur, but it should be remembered that under ordinary circumstances people do not remember the weather of the day before yesterday and when a person remarks that the "probs" are generally wrong, it is just as likely as not that he bases his judgment on the fact that they are wrong on the day of the remark and were astray on some day a month before when his occupation happened to be seriously affected by the weather.

In the opinion of the writer there are strong grounds for hope that with closer international co-operation and the freer use of the cable and wireless telegraphy, the next few years will see a marked improvement in both the accuracy and range of forecasts.

# STRANGE CELESTIAL VISITORS — COMETS AND METEORS *

By C. A. Chant

## I. Comets and Their Discovery

AT irregular intervals reports appear in the daily press of the discovery of new comets. No astronomical news is more readily printed, for the simple reason that the public has an insatiable desire for information about these strange bodies.

The astronomer can determine the exact position of a planet, or the precise circumstances of an eclipse, a thousand years ago or hence; but entirely without his knowledge a comet comes into view, stays with us a while, and then leaves our part of space — as far as we know, never to return. This, however, is not always the case as our recent experience with Halley's comet well illustrates. Some comets follow paths which are very well known, and return at regular periods.

Our first real information about these motions must be dated from the time of Newton and Halley. Newton showed that a body which revolves about the sun as an attractive centre must follow a curve known as a conic section — it must be an ellipse, a hyperbola or a parabola (Figure 1). An ellipse can vary all the way from a perfect circle, in which the two "foci" coincide, to a so-called "oval" form as elongated as we please. If we consider one end of the ellipse to be kept fixed while the other is removed to an infinite distance, the curve becomes a parabola. Perhaps the best illustration of an approximately parabolic curve is the path taken by a stone thrown into the air. If thrown up nearly vertically the path is narrow and long; this is approximately the shape of a comet's path — (Figure 2).

* Reprinted, with slight alterations, from *The Westminster* (Toronto), for September, 1911.

FIGURE 3.

From photograph of Faye's Comet, or 1910c, taken with the Bruce 10-inch telescope at the Yerkes Observatory. Exposure 2h. 9m. The short streaks are images of stars.

FIGURE 4.

Comet 1910d, discovered in South Africa on January 12. Photograph taken at the Dominion Astronomical Observatory, Ottawa, on January 28, 1910. Exposure 25 min.

It may be of interest to learn how information regarding astronomical discoveries is disseminated. By general agreement two central offices have been established, one in America, the other in Europe, for the receipt and despatch of astronomical messages. The central office for America is at the Harvard Col-

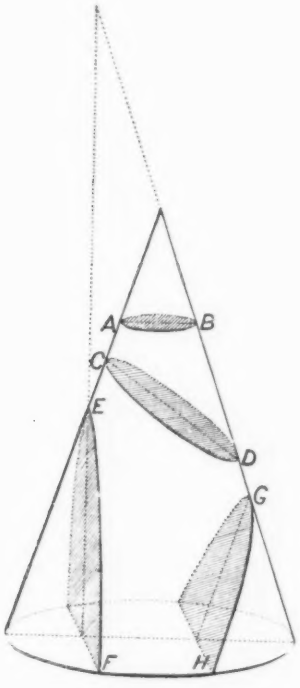



FIGURE 1.

A cone and its sections—A B is a circle, C D an ellipal, E F a hyperbola, G H a parabola.

lege Observatory, Cambridge, Mass., while that for Europe is at Kiel, in Germany. Usually when an American astronomer makes a discovery he telegraphs the news to Harvard, and from there it is cabled to Kiel. Then each central office spreads the

information throughout its own world. Telegrams in cypher are sent to most of the observatories, if it is essential that no time be lost. After this, bulletins, containing the same information, are sent by post, not only to observatories but to many libraries, societies and individuals interested.

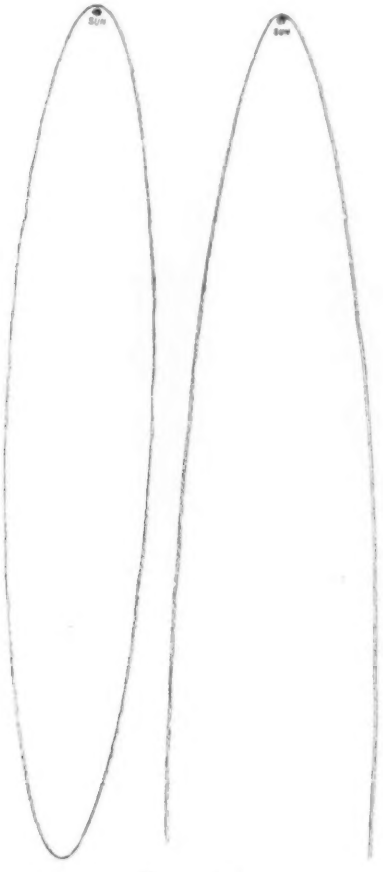


FIGURE 2.

An Elliptic and a Parabolic Path.

PLATE XII.

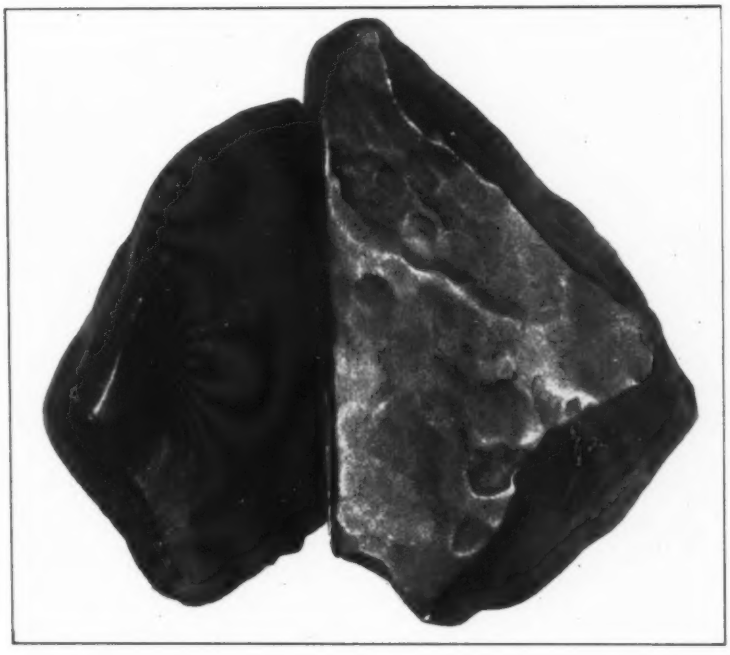


FIGURE 5.

The two Shelburne meteorites. This shows how the two stones were originally united.

Let us see how the method works out. On November 8, 1910, Cerulli, director of the observatory at Teramo, in Italy, discovered a comet. He does not appear to have communicated directly with Kiel, as the first *Bulletin* sent out from Harvard, dealing with this subject, was No. 430, dated November 10, and reading as follows:

> A cablegram has been received at this observatory from Professor Kobold, at Kiel, stating that Cerulli's comet was observed by Professor E. Millosevich, 1910, November 9·3131 days, Greenwich Mean Time, in right ascension 3h. 38m. 35·9s.; declination north, 8° 43′ 20″. The comet was visible in a small telescope.

In the first place, notice that the comet is known by the name of its discoverer, though as it was the fifth one discovered in the year it was also known as 1910*e*. When it is said that it was "observed," it does not mean that it was simply looked at, but that its position in the sky at the time was accurately measured. The time of observation is given in decimals of a day, not in hours and minutes, and it is referred to the time at Greenwich. This is the practice universally followed by astronomers and sailors. The terms "right ascension" and "declination" are used to locate a point on the celestial sphere, and correspond to longitude and latitude on the surface of the earth. The last statement in the despatch is not very definite. A "small telescope" may mean anything from three to six or seven inches in diameter. One would understand that the comet was not visible to the naked eye, or in an opera glass, but yet was not very faint.

This message immediately elicited observations in many quarters. *Bulletin*, No. 431, dated November 12, referred to a new star discovered at Harvard, and *Bulletin*, No. 432, of the same date, states that Cerulli's comet was observed by Epps at Washington on November 11·5801, in right ascension 3h. 38m. 27s., declination north 8° 9′ 11″, and was still visible in a small telescope. Then *Bulletin*, No. 433, dated November 14, states that Barnard, at the Yerkes Observatory, (University of Chicago), observed the same comet on November 11·7862 in right

ascension 3h. 38m. 25·3s., declination north 8° 5′ 58″; and that a spectrogram (*i. e.*, a photograph of its spectrum) taken by Parkhurst showed an "essentially continuous spectrum." In the same *Bulletin* is also given the position of the comet as observed by Professor Harriet W. Bigelow, of Smith College, Northampton, Mass., on November 12·6727. *Bulletin*, No. 434, dated November 15, states that Young at the Lick Observatory, (University of California), on November 13·8217, observed the comet in right ascension 3h. 38m. 14·8s., declination north, 7° 36′ 34″.

These messages indicate that the comet was being observed at many widely-separated stations; and it is to be understood, of course, that many measurements of position were not transmitted to the central office. Now as soon as three accurate observations of position have been made, it is possible to compute the path in space which the body is traversing. The path is taken to be either an ellipse or a parabola, and as it is much simpler to compute the orbit on the assumption that it is a parabola, this method is first followed. (It should be remarked, however, that the computation of an orbit of any kind is a very serious task). Hence we are not surprised to find in *Bulletin*, No. 435, dated November 16, the following:

A telegram has been received from Professor A. O. Leuschner, at Berkeley, Cal., stating that the following elements of Cerulli's comet have been computed by Meyer and Levy from observations made on November 9, 11, 13:—

ELEMENTS

Time of passing perihelion, 1910, November 19·49, G.M.T.

| | ° | ′ |
|---|---|---|
| Perihelion minus node | 200 | 17 |
| Longitude of node | 212 | 58 |
| Inclination | 18 | 17 |
| Perihelion distance | 2·196 | |

The observations do not admit of satisfactory parabolic representation and indicate short period. Probably identical with Faye's comet.

In order to specify the size and position in space of a parabolic orbit, it is necessary to give the values of the five quantities appearing in the above list. To explain them all here would

take too much space, but the first and the last are easily understood. The first states the time when the comet was nearest the sun, and the last gives its distance from the sun then. In this case the distance was 2·196 times the distance of the earth from the sun, or 204 millions of miles.

The last sentence of the *Bulletin* is interesting. After computing the orbit on the assumption that it was a parabola, a test was made to see if all the positions at which the comet had been observed would fit on the curve. The agreement was not satisfactory, and so it was surmised that the orbit was not a parabola, but a not very elongated ellipse, and, therefore, that the comet was a periodic one. On looking up a list of the elements of all known comets, one was found whose elements were sufficiently similar to lead to the suspicion that the two bodies were identical.

Messrs. Meyer and Levy must have continued their calculations without resting a moment, as we find that *Bulletin*, No. 436, issued next day, contains the elements of the orbit calculated by them on the assumption that it was an ellipse, as follows:

Time of passing perihelion, 1910, November 12·41.

| | ° | ′ |
|---|---|---|
| Perihelion minus node | 206 | 40 |
| Longitude of node | 205 | 29 |
| Inclination | 10 | 14 |
| Perihelion distance | 1·650 | |
| Eccentricity | 0·5459 | |
| Period | 6·93 years. | |

These elements confirm my previous identification with Faye's comet.

A month later, when sufficient time had elapsed to obtain observations of the comet's position far enough apart to allow the orbit to be determined more accurately, a new computation, based on positions measured on November 9, 23 and December 12, was made by the same men. The elements thus obtained differed somewhat from those last given, but were almost identical with those of Faye's comet published many years before.

Thus this comet was shown to be a regular visitor. It was discovered by Faye on November 22, 1843, and this was its tenth return to the sun since that time. It was known that it would

appear at about this date, but it had been overlooked by astronomers. Eighteen comets are known to have elliptic orbits, and that of Faye's is the least elongated of all. It is 706 millions of miles long and 582 millions across.

After all this labor one might expect that the comet would be a striking object to see, but such was not the case. In Figure 3 is reproduced a photograph taken at the Yerkes Observatory by Barnard, on November 10, with an exposure of 2h. 9m. A slight tail is visible. It might be remarked, however, that most of the comets which are reported are not more striking in appearance, though 1910*a* was an exception. A picture of this beautiful body is given in Figure 4.

Another periodic comet, due to return to the sun in 1911, is Wolf's. It was discovered in 1898 by Professor Max Wolf, of Heidelberg, and its period is 6·8 years. It was not seen in 1905, on account of its unfavorable position. *Bulletin*, No. 441, dated February 27, 1911, gives an ephemeris of the comet, *i. e.*, a list of positions it will occupy as seen from the earth on certain dates. Four months later, on June 21, *Bulletin*, No. 444, states that the comet was observed on June 19 by Wolf himself, and that the comet was "visible in a large telescope." This being the first comet discovered during the year, it is known as 1911*a*. Not since 1897 had so large a portion of the year elapsed without the discovery of a comet, and yet before the year had closed eight comets had been discovered, an exceptionally large number.

The next *Bulletin*, No. 445, is dated July 7, and is as follows:

> A telegram from Professor R. G. Aitken, of the Lick Observatory, states that a comet, discovered by Kiess, was observed by Kiess, July 6·9794, in right ascension 4h. 51m. 51·8s., declination north 35° 15′ 2″. The comet can be seen with an opera glass. It is moving southwest and has a visible tail.

The position here given is in the constellation Auriga (the Charioteer), which is visible during the summer months in the early morning in the north eastern sky. The rapid motion southwards soon carried this comet beyond the reach of northern observatories, but in the southern hemisphere it was visible up to the end of the year, though then very faint.

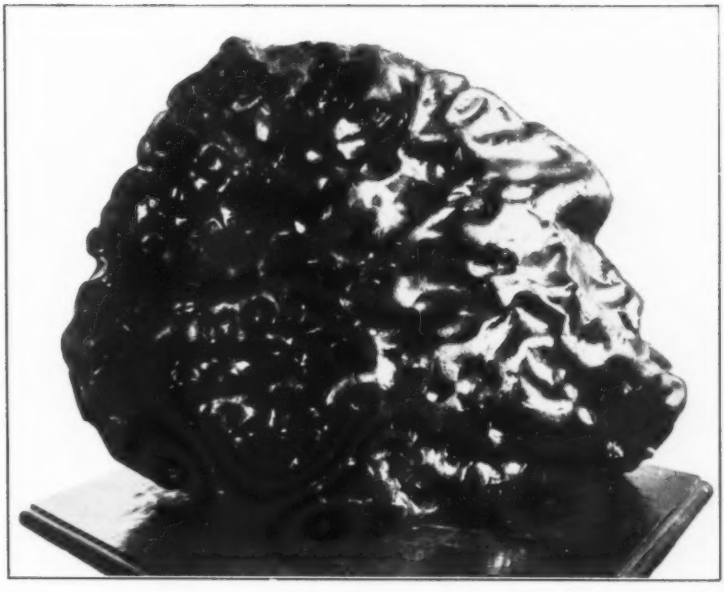


FIGURE 6.

An iron meteorite in Victoria College, Toronto.

## II.—Meteors and Meteorites

The familiar phenomenon of shooting stars can be seen on almost any clear night by watching the heavens for a short time. The bright streaks in the sky are caused by material bodies rushing through the earth's atmosphere, the friction met with by the body causing it to become incandescent. Occasionally the streak is very brilliant, being apparently caused by a much larger or much nearer body. All such phenomena are classed as meteors.

Sometimes the speed of these bodies is so reduced by the friction that they forsake their old paths, and the earth attracts them to its surface. Some of them are actually seen to fall and are picked up afterwards. They are known as meteorites. Since the year 1800 about 300 of these bodies have fallen and been gathered into our museums.

An interesting example occurred in 1904. At 8 p.m., on August 13, a very brilliant meteor was seen over a large part of Western Ontario. The present writer at the time was in a rowboat on Go Home Bay, and the meteor, which was seen almost directly south, appeared like an arc lamp falling almost vertically. From Toronto the meteor was seen to the northwest; from Stratford, to the northeast; from Owen Sound, to the southeast; and so on from other places as far as eighty miles away. In a day or two the newpapers published the fact that the fall had taken place near the village of Shelburne, Grey County.

In the immediate vicinity of the place the fire-ball itself was not seen, but a strong flash of light illuminated the surrounding locality. An extraordinary sound, described as "distant thunder," "boom of cannon," "drum-beat," "musical tone," "hissing noise," etc., accompanied the fall, and was heard as far as 35 miles away.

Among those who heard it was the family of Mr. John Shields. To them the sounds were like a muffled drum-beat, followed by a dull thud at the rear of the house, as though an old shed at the back had fallen. On investigation the shed was found intact, but a newly made hole was noticed in the soil near

it. It was also observed that the side of the house was splashed with mud.

At first there was a feeling of incredulity that this hole could have been made by a real visitor from the sky, and little was done next day (Sunday) to investigate. However, on Monday morning the hole was examined, and at the depth of about two feet a strange black stone was found. It had descended within two feet of the house, and from the depth to which it sank in the earth it was computed that its speed was about 180 yards per second or 6 miles per minute!

On the evening of August 13, Mr. George Johnston, who worked his father's farm, about three-quarters of a mile north-west from Mr. Shields' place, felt certain that something had fallen in his oat field; but he would not allow his grain to be destroyed in a search for it. On the 31st he began to cut his oats, and a sharp watch was kept from the seat of the self-binder for any signs of the body. At about 10 a.m. the machine passed over a freshly-made hole on the side of a knoll, and on digging into the light soil another black stone was found at the depth of about two feet.

The first stone weighed 12¼ pounds, the second 27¾ pounds. they were both covered with a thin black crust, and the surface bore the characteristic "finger-marks," such as are made by thrusting the thumb into putty.

Of course the recovery of the second stone kindled the interest afresh. A telephone line superintendent, who happened to be in the neighborhood, offered $200 for it, and obtained it. Some time afterwards he sold it to Queen's University, Kingston, for, I believe, $276.* The smaller stone, several months later, was sold to Dr. Farrington, acting for the Field Columbian Museum of Chicago.

Both stones were submitted to a close examination and analysis, and were found to contain the following minerals:—Nickel-iron, 8·5 per cent.; troilite, 4·5; chromite, 0·8; schreib-

* For a full account of this meteorite see the TRANSACTIONS of the R.A.S.C., for 1904.

ersite, 0·4; olivine, 45·0; enstatite, 27·8; aluminium-silicate, 13·0. These substances are all common enough on the surface of the earth, but the peculiar way in which they are combined in a meteorite is never seen in any substance of terrestrial origin. Not all meteorites, however, are of this stony nature. About three per cent. are almost of pure iron, but united with nickel in a way not met with on our planet. A mineralogist, by a short examination, can make sure whether a body is a genuine meteorite or not. In Figure 5 is shown how the two Shelburne stones were originally united.

A fine specimen of an iron meteorite is in the possession of Victoria College, Toronto, a picture of which is given in Figure 6. It was found on a hill near Iron Creek, a tributary of the Battle River, at a point about 150 miles south of Victoria, on the North Saskatchewan, and in 1869 was brought out by the well-known missionary, George McDougall. The meteorite was greatly venerated by the Indians, who made offerings to it of beads, trinkets or knives before setting out on hunting or war-like expeditions. The Indians saw in the markings of its surface the rough features of a human face. They believed that the "stone" attracted lightning and that it had grown in size since they first saw it. It is of solid metal, and weighs 386 pounds. Its specific gravity is 7·784, and its composition is: Iron, 91·33; nickel, 8·83; cobalt, 0·49.*

### III.—Relation of Comets to Meteors

Comets and meteors are very interesting objects in themselves, but we have now good reason for thinking that there is a connection between them, and so the interest is intensified.

At certain times in the year meteor "showers" are seen, and if in each of these displays the bright streaks are produced backwards, they are seen to diverge from a single point. This point is called the "radiant" of the shower. Thus, about November 15 a shower with a radiant in the constellation Leo (the Lion) is seen; these are called the Leonids. The Andromedes,

* A. P. Coleman, in Transactions of the R.S.C., 1886.

with radiant in Andromeda, are seen on November 27 or 28; the Perseids, with radiant in Perseus, early in August; and so on. About 100 meteoric radiants are now recognized and catalogued. It is believed that there are "swarms" of these bodies moving about the sun, and at certain times of the year the earth is moving sufficiently near them to produce a meteoric shower. Treating the swarm as a concrete mass, it is possible to compute an orbit for it. Adams, the English discoverer of Neptune, did this for the Leonids; and the orbit was found to be identical with that of Tempel's comet of 1866. Schiaparelli, of Milan, determined the orbit of the Perseid or August meteors, and it turned out to be the same as that of Tuttle's comet of 1862. In 1872 the Andromedes were found to be following the track of Biela's comet. This comet was discovered by Biela, an Austrian officer, in 1826, and a French scientist, Gambart, soon showed that it was periodic, with a period of 6·6 years. Its orbit was so placed that it could come quite near the earth, and the report that there would be a collision between the two bodies in 1832 caused a panic in southern France, which the great scientist Arago was called upon to allay. At the comet's next return in 1839, it was not observed on account of its unfavorable position. However, in 1846 it duly reappeared, but it was seen to be broken into two! In 1852 the two parts were seen again, but never since that time. But on the night of November 27, 1872, when the earth was passing through the old track of the lost comet a wonderful meteoric shower was encountered, and the same thing happened, though not as striking, in 1885 and 1892. One or two other similar coincidences have been demonstrated. These cannot be purely accidental; and thus we have good reason to believe that there is a real connection between comets and meteors; that, indeed a comet in the course of time disintegrates into a swarm of meteors, which are distributed along a large part of its path.

# ASTRONOMY AS A RECREATION*

By Joseph Pope

"ASTRONOMY as a recreation." I think I hear someone say: "This man must be an unconscious humorist! Astronomy is, no doubt, a very elevating and noble pursuit. But is it not, at the same time, one calling for the exercise of the highest intellectual faculties? Does it not demand, in addition to long years of profound study, immense constancy, patience and perseverance, laborious days, sleepless nights and an utter abnegation of all mundane pleasures, to enable one to qualify as an astronomer? And, we are told forsooth, that this abstruse and all-engrossing study may be viewed as a pastime! Surely the title of this paper is a contradiction in terms."

Upon this point the testimony is overwhelming. Every passing allusion to astronomy in the literature of the day — or of past days, for that matter — confirms the prevalent theory that, even in its simplest phase, it is quite beyond the comprehension of the ordinary mortal. That brilliant statesman and thinker,— perhaps, more brilliant as a thinker than as a statesman — Lord Rosebery, is credited with the observation that he would not advise any one to go in for amateur astronomy, that unless you are versed in mathematics, optics and half a dozen kindred sciences, you can never hope to make anything out of it,— which shows clearly to my mind that, on this occasion at any rate, Lord Rosebery has followed his own advice, a thing which, by the way, he does not always do. Now with all deference to the noble lord whom I have just quoted, and to the legion of those who, so far as they think on the subject at all, are disposed to agree with him, I unhesitatingly affirm that not only is astron-

* A paper, somewhat abridged, read before the Royal Astronomical Society at Toronto.

omy one of the loftiest and most ennobling subjects that can engage the human mind, (in which we are all agreed), but it is at the same time one of the most fascinating of intellectual pursuits. Moreover, it is the one science above all others that offers almost boundless interest to the amateur, with the least possible labor, inconvenience and expense. Suppose, for example, you are minded to go in for chemistry for a recreation. You have first to learn something of the nature of the substances with which you propose to experiment, otherwise you are very apt to poison yourself, or blow yourself up. You have to provide yourself with a laboratory, and lay out a certain amount of money on an equipment, before you can make a start. So also with geology. You have to master a huge number of technical terms, to take long tramps, to climb mountains, to break your back cracking stones on a hot day. So it is with almost any science you can name. Even gardening has its inconveniences. But from astronomy you can derive an enormous amount of pleasure and satisfaction without straying from your own doorstep. Your equipment is provided for you. All you have to do is to lift up your eyes, and draw upon your powers of observation and reflection to a very limited extent. I do not deny that a telescope adds greatly to the pleasure of the study, but its cost need not be great, with proper care it will last a life time, and in any case it is not indispensable. Let us begin without one.

And now you are placing yourself under the guidance of one whose acquaintance with the things of which he is going to speak is of the most elementary character; who is possessed of no technical knowledge of astronomy; who has long ago forgotten the little mathematics he learned when a boy; whose life has been spent in earning his living, in pursuits far removed from the stars; but who from a child has accustomed himself to lift up his eyes and behold the wonders of the heavens; whose ears have not been quite deaf to the music of the spheres; and whose artistic tastes not wholly indifferent to the masterpieces of creation. Do not be afraid of getting beyond your depth — I could not lead you there if I wished. Nor do I propose to say

anything that a child of tender years could not follow with perfect ease.

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I suppose the least reflective person that ever lived, is conscious of the fact that day and night are due to the apparent movement of the sun. Day after day we see him — or can see him if we are so minded — rise in the east, mount the sky till he reaches due south, and then gradually descend to the western horizon, to reappear in the east next morning. It does not require any superhuman effort to perceive that the moon and the stars do the same thing, and thus the conviction is forced upon our minds, either that the world we live in is rotating once in twenty-four hours, or else that it is the centre about which the whole company of heaven is good enough to turn.

But that is not all. We are, perhaps, looking at the sunset, — it may be from the depths of an easy chair, enjoying a quiet cigar, after the labors of the day. Very shortly after the sun's disappearance, we note that charming spectacle, the crescent moon, "like to a silver bow new bent in heaven," and, quite near, perhaps, a gleaming star. The sight is so captivating that next evening we look for it again, but the combination is no longer there. The new moon has travelled far to the eastward, and appears quite a distance — about twenty-six times its own breadth — from the star. Night after night it backs farther and farther away, until in a month it has circled completely round the heavens, and shows up again in the western sky. Now this movement is obvious. It can be seen simply by using one's eyes. Nor does it involve any severe mental strain to deduce therefrom that there must be more motions above than one. It is plain that everything cannot be going round in one piece, as it were, for the moon, while sharing in the diurnal revolution, is manifestly moving among the stars on her own account.

These two phenomena, the apparent daily rotation of the firmament about the earth and the monthly sweep of the moon round the heavens, are gross, palpable facts, patent to any one

who takes the trouble to look at them.

If I have succeeded in interesting you so far, we may proceed to consider certain other motions in the sky, less rapid and conspicuous than those I have indicated, but still readily discernible.

Those who have given the matter the slightest thought, must have noticed that we do not see the same stars in the same place, at all seasons of the year. For example, the grand constellation of Orion that adorns our winter skies, is not always in the same part of the heavens at the same hour, and in summer is not visible at all. A little very ordinary observation will enable us to discern the reason for this.

If you look out at nine o'clock in the evening about the 1st of December, you will see the well known Orion rising in the eastern sky. At New Year at the same hour he is considerably farther up. By February he is at his highest point — due south. On the 1st of March he is well to the west, and in April he hangs over the west horizon. In May he is no longer visible, but in the following December you will see him rising as usual.

Each star rises about four minutes earlier every successive evening, and consequently sets earlier by the same amount of time, for the paths of these stars never change, they continually pursue the same courses. They never get off the track. Although for six months of the year we do not see Orion, yet Orion is always there. He is due south in our sky once every twenty-four hours, and if we mortals do not always see him, it is because of the sun which blots out his feeble light. The stars then are always slowly moving towards the west, or what is the same thing, the sun seems to be moving eastward to meet the stars. That is to say, apart from his diurnal motion, the sun is actually moving backwards among the stars from west to east, just as we saw that the moon does, only with this difference. The moon goes completely round the heavens once a month, while the sun takes a year to complete his circuit. His motion, therefore, being slower, is less conspicuous. Morever, we can readily mark the moon's eastward path by referring her to the stars which lie near her course. No such plan is directly possible

with the sun, because we cannot see the stars lying near him. But if we watch the first stars that glimmer in the western sky after sunset, we shall find that evening after evening they sink lower and lower until they disappear from sight, having apparently fallen into the grave of that luminary, while fresh constellations which have risen in the east, and passed the meridian, are ever following in the same downward path.

There is still more to note about the habits of that wonderful luminary, the sun. At the present time of year (December) the sun rises in the southeast, traverses a small arc in the sky and sets in the southwest. On the 21st December he rises at his most southeasterly point and sets at his most southwesterly — and hence is above the horizon the shortest time possible. Every successive day thereafter he rises a little nearer to the east point — backs away from the south, as it were — traverses a wider arc in the sky, and sets a little nearer to the west point until on the 21st March he rises due east, and sets due west, and the days and nights are equal. Still backing, he rises each day farther north, until the 21st June, which is the longest day. He then begins to retrace his steps, rising nearer and nearer to the east each morning, until on the 23rd September he rises due east and sets due west, and the days and nights are again equal. Continuing his wintry flight, he finally reaches his southern limit on the 21st December, and like Goethe's star, "without haste and without rest," begins anew his progress towards the north. If you mark the places of his rising and setting by referring to an object on the sky line — a house, a tree, or anything of that sort — you can observe these motions with the greatest ease.

I hope I do not bore you, for I have not yet exhausted the motions visible above. I have spoken of the sun, moon and stars, but in addition there are five bodies, which though commonly classed with the stars, differ essentially therefrom in that they move on their own account. They are called planets, from a Greek word meaning "wanderers." The stars never change their relative positions towards each other. Century after century, age after age, they form exactly the same groups in the

sky. As the ancient Egyptians beheld them in the beginning of history ; as they shone down on Abraham in far off Mesopotamia four thousand years ago — so do they appear to us to night. The planets on the contrary, are perpetually shifting their places — now apparently drawing near the sun — now receding from him — now moving in one direction, then stopping and backing up for a while, only to resume their original course, yet always keeping within a narrow belt in the sky.

These planets are Mercury, Venus, Mars, Jupiter and Saturn, but space will not allow a detailed description of their motions.

Let me here briefly recapitulate what our unaided observation shows us :—

1. We have seen that the vault of heaven apparently turns round on itself, once every twenty-four hours.

2. That the moon, while sharing in this general rotation, circles about the earth from west to east once a month.

3. That the sun apparently makes the same circuit, only instead of performing the journey in a month, it takes him a year — in the course of which he oscillates north and south through an arc of about forty-seven degrees with undeviating regularity.

4. Lastly, that there are five stars lying near his track and that of the moon, which behave in an extraordinary fashion — advancing, retreating, standing still, but which on the whole travel round the sun at varying intervals running from 88 days in the case of the closest and most nimble, to well nigh 30 years, in the case of the farthest and least active. These then are the phenomena which presented themselves to the gaze of the ancient observers of the sky, and sorely must they have perplexed them. Their first attempt at a solution of the diurnal turning of the heavens was that the earth stood unmovable in the centre of the universe — that all we see above was fixed in a crystal sphere which revolved daily about the world.

I have not time, nor, I fear, the requisite knowledge to

explain in any detail the cumbrous machinery whereby the ancients sought to reconcile these various motions with the immovability of the earth.

Once the true position of the sun was recognized, the wayward motions of the planets in our skies became clear. On the assumption of an immovable earth they were well nigh inexplicable; but start the earth moving round the sun with the other planets, and the mystery is solved. What seemed intricate and involved beyond measure, becomes simplicity itself. Here is a striking illustration of the truth of the observation that everything depends on the point of view. The movements of Mars or any other planet as seen from this earth at rest, are, indeed, a puzzle. But when we come to realize that we are moving also — that both of us are circling about a common centre — then it becomes at once apparent that the convolutions of the planets are only partly real — that they are a combination of our own motion with theirs. Could we stand on the sun, in the centre of our system, and view the planets circling about us, all these complexities would disappear, and we should see the several planets holding their majestic courses through space with the most perfect simplicity and regularity.

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I have briefly referred to the principal motions of the heavenly bodies that are apparent to our eyes. You know now that when the heavenly bodies appear to rise and set daily, it is not *they* that are turning — it is the earth on which we stand that is rotating once every 24 hours. When, with an independent movement, the stars appear to be forever disappearing in the west, it merely means that the earth is travlling round the sun, and thus presents to our view, in the hours of darkness, different portions of the heavens at different seasons — exposing the whole panorama in the course of a year. Once a month the moon travels round the earth, presenting different phases, because the sunlight is falling on her at different angles. The to-and-fro motion of the sun north and south of the east and west points,

is simply due to the inclination of the axis of the earth, which causes the north pole to bend alternately toward and away from the sun. Surely the ability to read these pages of the book of nature, should fill us with a genuine satisfaction.

"Well, suppose it does," I think I hear some one say, "that is not quite the same thing as *recreation* — where does the purely recreative part of astronomy come in."

I had not forgotten the lighter aspect of the science, but before touching upon it I judged it desirable to make a general review of the celestial mechanism. Having done this, I will now proceed to show how it is possible to spend many a delightful hour in exploring the mysteries of the skies.

For this a telescope is necessary. Now a telescope to the uninitiated is apt to suggest a costly instrument with a correspondingly expensive equipment — an observatory with its revolving dome and all sorts of complex contrivances. But this is another of the many fallacies which obscure the pursuit of astronomy. The very slightest optical aid proves of immense assistance in the study of the skies. An opera glass will disclose wonders. A telescope, having an object glass of two inches in diameter, will, of course, show much more — while a three-inch glass will prove a veritable mine of pleasure. Such a telescope requires no elaborate equipment. You can tuck it under one arm, and carry it and its stand along with you till you find a suitable spot for observing — as far removed as possible from the glare of electric lights and the tremor of passing trains or street cars. For $75 one can obtain an excellent glass, and often one can be picked up for half the money. I once had a good glass which I purchased second-hand for $30.

Now just one word as to the mechanism of a telescope. The principal feature is the glass at the far end, called the object glass. When we speak of a two or a three-inch glass, we mean that the breadth of this glass is two or three inches from rim to rim. It costs more than the other parts of the instrument put together, and upon its quality the excellence of the instrument mainly depends. Let me, in passing, urge you never to wipe

this glass if you can possibly help it. The cumulative effect of wiping or rubbing can be seen by holding up an old pair of spectacles to the light. Better far a little dust, than those unsightly scratches every one of which means so much loss of light. The function of this glass is to form an image of the objects to which it is directed, and the eye-piece, which is really a microscope, magnifies this image before it enters the observer's eye. These eye-pieces are not expensive and can be slipped in and out of the telescope with great facility. A good telescope is supposed to bear a magnifying power of 100 to every inch of the object glass, but this presupposes perfect conditions of both glass and atmosphere. It is a mere theoretical perfection, and in practice few glasses will be found to bear with advantage more than half that power.

Let us now suppose ourselves the happy possessor of a good 3-inch glass, fitted with four eye-pieces, magnifying say 40, 80, 110 and 200 diameters respectively. We adjust the 110-power eye-piece and point our telescope to the new moon, remembering that it is the property of an astronomical telescope to invert the object, so that north appears south, and south north. Inasmuch, however, as the heavenly bodies are globular in form, the inversion, so long as we remember it, is of no practical disadvantage.

It is difficult for one who looks for the first time through such a telescope as I have described, to repress a cry of wonder and delight as his eye is suddenly illuminated with the charming spectacle which meets his gaze. The marvellous brightness of the golden sickle of the new moon; the clear cut form of the mountains, craters and valleys that lie before him; the startling contrast afforded by the shadows flung across the brilliantly lit plains, fill him with astonishment, while the thought that he is actually looking upon scenes in another world — all these combine to impart a feeling of unmixed pleasure. The sight, of course, can be varied by changing the eye-pieces. The low power of 40 will enable the observer to view the moon as a whole — that is to say to include it all within the field of view — while

200 may be employed on exceptionally fine nights to study the formation of some individual plain or crater. With the growth of the crescent, new objects are continually carried into view as the sun rises upon them, and the march of the advancing light forms a most entrancing picture. One sees near the dividing line between the light and dark portions of the moon, bright touches of gold amid the surrounding gloom — these are the mountain tops catching and reflecting back the sunlight while their bases still lie in the shadow. Contrary to general expectation, full moon is the least attractive of the lunar sights, for the reason that the whole sphere is flooded with the sun's radiance — there is no light and shade — no shadows to be seen — everything is bathed in a silvery glow, and the picture becomes less enlivened with variety.

One of the most interesting of phenomena to the amateur astronomer is to observe occultations of stars by the moon. We have seen that our satellite travels round the sky once a month. This motion is fairly rapid — indeed the moon moves towards the east, a space equal to its apparent breadth every hour. It is inevitable, therefore, that she should frequently come between us and a star. Astronomers call this "occulting" the star, and these various occultations are all predicted beforehand and recorded in the Nautical Almanac. There are two forms of occultations. One when the star disappears behind the dark side of the new moon, the other when it is first covered by the moon's bright limb. The first is more often witnessed by amateurs, for the reason that it takes place at a more convenient time in the evening when the dark side of the new moon is the one advancing towards the east, and consequently is the side to overtake and extinguish the star. The reverse process takes place in the case of the waning moon seen in the small hours of the morning, for then the bright side leads the way. The way to watch an occultation is to find out from the Almanac when it is going to take place, hunt up the star with your telescope a few minutes before hand, and watch the dark (though generally visible) body of the moon encroaching upon it. Gradually it steals along,

ever drawing nearer and nearer, until suddenly out goes the little star. The instantaneous disappearance of an occulted star is one of the most interesting features of the phenomenon, and is a standard proof of the non existence of an atmosphere on the moon. For, were our satellite surrounded with an envelope of air, it is manifest that the star would lose its light gradually (owing to the interposition between us and it of the lunar atmosphere) before it was actually blotted out of sight by the dark body of the moon. Instead of this, the star shines with its accustomed brightness right up to the last second, and disappears with startling suddenness, to reappear on the other side of the moon in a manner equally abrupt. The time of an occultation varies with circumstances. If the central portion of the moon comes square between us and the star, it takes about an hour, but the star may disappear behind the moon at any angle, or the moon may just graze it -- sometimes escape it by a hair's breadth, in which case the phenomenon is known not as an occultation, but as a "close approach." I wish I could convey to you the sense of importance which invests an amateur when he has successfully observed the occultation of a star or planet by the moon. The 40-power eye-piece is commonly the best for occultations, as it enables you to view the whole of the advancing limb of the moon, as well as the intervening space between it and the star.

But we must pass on. Jupiter is, perhaps, the easiest of all planets for the amateur observer. There is a charm about him which no possessor of a telescope can resist. You turn your three-inch glass upon him with a power of 110, and a great white globe floats into view attended by four satellites of a golden hue.

The first thing that strikes you about Jupiter is his oblate form. He is quite perceptibly flattened at the poles and correspondingly bulged out at his equator. This is due to his swift rotation. Jupiter turns on his axis in 10 hours -- about two-fifths of the time our earth takes to rotate, and as he is immensely larger than our globe, it follows that a point on his surface, par-

ticularly if near his equator, must move with great rapidity. Consequently the markings on his face seem to be perpetually shifting as the great planet turns round under our eyes.

Jupiter's disk is marked with certain horizontal bands commonly called "belts," which extend across the surface of the planet. In telescopes such as ours, these belts are usually of a dusky hue. They change in number and breadth from time to time, sometimes exhibiting curious and beautiful scalloped forms. One night will reveal a difference in this general aspect, owing to the swiftness with which Jupiter turns on its axis.

Undoubtedly, the most interesting of all the phenomena presented by Jupiter, are those connected with his satellites. These little moons are four in number, and their ceaseless changes of position invest them with a peculiar fascination. The innermost satellite revolves about Jupiter in 42½ hours, the second in 3½ days, the third in 7 days, and the fourth in 16½ days. To-night they may appear two on each side; to-morrow night, three on one side and one on the other, and so on. Sometimes one satellite may be behind the body of Jupiter while another is crossing his disk, that is, coming between us and him, in which event one frequently sees, not only the satellite, but also its shadow like a little black spot on the face of the planet. To see the tiny moon edge up close to its great primary, preparatory to disappearing behind its huge body, or to be projected on his face, is an absorbing pleasure. Perhaps, still more entertaining are the frequent eclipses which the satellites suffer by getting into Jupiter's shadow. The exact second of these eclipses, both as regards disappearance and reappearance, is predicted in the Nautical Almanac. Suppose, for instance, the third satellite is scheduled for eclipse at 16 minutes and 10 seconds past 9 o'clock p.m. You have your telescope ready, at say 9.15. You turn it on Jupiter. The third satellite is shining like a little golden bead. You are watching it closely. At 9.16 its appearance is unchanged. A few moments later, however, it begins to pale, and quickly is completely extinguished. The disappearance is not so startlingly sudden as the occultation of a star by the moon,

for the little satellite, being a body of considerable size, takes a certain time to roll into the shadow ; still it is very rapid, not taking more than a few seconds.

Again, supposing the Almanac says that the second satellite will re-appear on the left side of Jupiter at 10.27 p.m. You have a friend with you, and have been showing him Jupiter, who is riding high in the sky, accompanied by three of his moons. Number 3 on the left, numbers 1 and 4 on the right — so your friend, who has his eye to the glass, tells you at 10h. 26m. 30s. You reply that he must be mistaken, that the configuration in the Almanac shows two moons on each side of Jupiter for to-night. He looks again, and lo, even as he gazes, a little moon gradually emerges from the darkness, and serenely takes up its position alongside of number 3, as though nothing had happened. All this occurs 450 millions of miles away, yet the godlike intelligence of man has bridged this vast gulf, and predicts with unerring accuracy what is going to happen in these distant worlds. And without any trouble or inconvenience on our part, we are permitted to enjoy this spectacle at our ease. Am I not right in calling this "recreation?"

Before tearing ourselves away from this most attractive planet I may just say one word as to the much debated question of the visibility of Jupiter's moons to the naked eye. It has been alleged that individuals gifted with rarely acute vision have detected one or more of these tiny objects. Thus, a German named Nernst asserted that he saw one satellite, and drew a diagram of its position — but when the telescope was applied, it was found that three satellites had approached very near one another, and their united brightness had caught the piercing eye of the observer. Miss Clerke tells the story of a Siberian who stated that he had seen "a bright star eat up four little stars and cast them up again," which exactly describes the eclipses, transits and occultations of these moons, as they would appear to the untutored eye of a savage. There is no doubt that the closeness of these little bodies to Jupiter is the main reason why, at any rate, the third satellite cannot be seen, for could it be viewed by

itself against the dark background of the sky, it is large enough to be readily visible to a keen eye. Whether it, or the whole four, have been detected in the bright light of the planet, is doubtful. For one cannot help asking the question how is it the ancients did not see them? There was no suspicion of their existing until Galileo pointed his telescope to Jupiter on the 7th January, 1610.

The most interesting planet to the telescopic observer after Jupiter, is Saturn. Saturn shines with a dull white light. Owing to its vast distance from us, it is by no means so bright as Jupiter, nor are its markings so distinct. Belts it has, but they are shadowy and ill-defined. Saturn has many moons, but only one conspicuously visible in a three inch telescope. It is called Titan, and is about the size of the planet Mars. Neither it or its fellows, even in the largest telescope, compare in interest with Jupiter's moons. This is owing partly to their deliberate movements, and partly to the inclination of the plane of their orbits to that of Saturn. Consequently they do not appear to come between us and their primary to anything like the extent as do the moons of Jupiter.

But what is lacking in Saturn's moons is amply made up for in the wonderful rings which encircle the planet.

There is a division in the main ring which shows like a narrow black line running round the entire length. It is said to be easily visible in a good 3-inch glass, but I never succeeded in seeing it with such an instrument.

The rings, however, show up perfectly well, except at intervals of 15 years, when, owing to the relative position which Saturn occupies to the earth at these periods, we see the rings edge on, which means we do not see them at all. Just now they are exceptionally well placed for observation, and there is this compensating advantage about Saturn, to make up for his immense distance from us, that for some reason, of which I am ignorant, he bears magnification better than any other planet. Where Jupiter will stand a power of 100, one can commonly use 150 on Saturn.

Mars is, perhaps, the next most interesting planet under the telescope, though occasions for viewing him with advantage do not often occur. Mars is the first planet outside the earth. We go round the sun in one year, Mars in 687 of our days. As we both go racing round, it is obvious that sometimes the earth catches up to Mars, and Mars, the earth and the sun are in a straight line, the earth being in the middle.

If the orbits of Mars and the earth were both circular, these two planets would come as near to each other as possible every 26 months. Unfortunately, while our path round the sun is nearly a circle, that of Mars is very distinctly oval, or more correctly, elliptical in form, so that sometimes when we are both in line with the sun, the interval separating our orbits is much greater than at other times. When the two planets happen to pass each other at the point where their orbits make the closest approach, which happens once in 15 years or thereabouts, Mars glows like a great red star in the heavens, but even then he is not particularly interesting in a 3-inch telescope. With a power of 110 one can see white patches at his poles, which are supposed to be snow, and certain of the bolder markings are just visible. The famous canals are quite beyond anything but the largest instruments.

We come now to Venus, the beautiful evening star, which under certain circumstances approaches us more nearly than any other of the heavenly bodies, the moon only excepted. On these occasions she shows as a slender crescent. A moment's reflection will show why. Venus travels round the sun in an orbit interior to that of the earth. As she is a dark body shining only by reflected sunlight, it is manifest that she must undergo to us the phases of the moon. When she comes directly between us and the source of her illumination, that is the sun, she must have her dark side turned toward us, and consequently is invisible. As she moves onward in her course, she gradually turns her bright side towards us, and consequently shows first as a crescent, then as a semi-circle, and lastly with a full face, though we never see her full, for the reason that being then on the far

side of her orbit with the sun between us and her, she is lost in the solar brightness. It is when she is on our side of the sun, she shines best, the loss of illuminated surface being more than compensated for by her nearness of approach. It is, therefore, as a half moon or crescent that we propose to view her.

Now it must be confessed that like Mars, Venus is a disappointing object. This arises from her very beauty. She is so brilliant that we cannot detect any markings upon her. She appears to be perpetually swathed in cloud, so that after we have gratified our eyes by looking at this dazzling little miniature moon, there is really nothing more to see.

Mercury being a planet lying interior to us, of course puts on the same phases as Venus. Our telescope will show him on favorable occasions as a tiny crescent, but he is always near the sun and there is considerable difficulty in picking him up.

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I have now gone over the principal sights of the solar system, but the telescope can show us much of interest lying in the vast beyond. Indeed, when one has grown familiar with the sights I have endeavored to describe, one naturally wishes to know what there is to be seen in the universe that stretches out on every side beyond the planetary worlds.

Now you can never expect to see the stars as you behold the planets. As regards the latter, we see their solid bodies, and in most cases we can reasonably infer that they consist of geographical divisions analogous to those of our own world. But with the stars it is quite different. They are so immensely distant that the most powerful telescope fails to disclose a real disc — they are merely points of light, and all the telescope can do is to magnify their brightness, without increasing their apparent size. Their great attractiveness consists in the fact that many of them are double, some triple, some even quadruple. Generally the main star is much brighter than its companions. Occasionally, however, in the case of double stars the component parts are of almost equal size. Many of these double stars are plainly visible as such in a 3-inch telescope. To take a very

easy case. In the constellation of the Great Bear, the second star in the handle of the "dipper," known as *Mizar* has just above and almost touching it, a tiny star called *Alcor*. These form what is called a naked eye double — that is to say, the smaller star is visible to one of ordinarily good sight. With a 3-inch glass, *Mizar* shows as two bright stars, brilliantly contrasted in color, the larger being white and the smaller blue-green, while *Alcor* seems some distance away, and in the intervening distance are several faint stars. The lonely star called *Cor Caroli* some little distance below the first star in the handle of the dipper, is a wide double. One of the finest double stars in the whole heavens is Castor, the uppermost of the twins Castor and Pollux. A power of 110 is sufficient to separate its components, which are of almost equal size. The star called *Beta Cygni*, which forms the foot of the Cross lying under the bright star Vega, is, perhaps, the most beautiful of all the double stars. It is formed of two components, light yellow and deep blue, presenting a sharp contrast. This is an extremely easy object in a small telescope.

Speaking of Vega, there are two little stars towards the east, which form with Vega a small triangle, whereof Vega is the apex. Look at the northern of these two stars. An opera glass will divide it into two twinkling points. Now take the 3-inch telescope with a moderate power. Each of the two stars revealed by the opera glass appears double, and a tiny star is seen on one side of an imaginary line joining the two pairs.

And so I could go on indefinitely, but I fear I have trespassed on your patience as it is. Let me assure you that the whole heavens is a perfect mine of wonders, which declare the glory of God as nothing else vouchsafed to our mortal senses. A whole evening might be spent in contemplating — let us say the great nebula in Orion, which is, perhaps, the most stupendous work of Omnipotence of which we have knowledge. That sight is visible, though not, of course, in its full glory, in a 3-inch telescope.

I am very sensible of the fact that in the course of my remarks I have said many things that must have made astronomers present, stare and gasp. Astronomy is beyond all others an exact science, and I have not pretended to exactness. On the contrary there is hardly a statement I have made that does not require qualification. The paths of the planets are *not* in the same plane as that of the earth's orbit. Their orbits are *not* circular. The fixed stars do *not* maintain their relative distance towards each other — on the contrary, they are all in motion. My object, however, was to lay down a few general principles, and not to weary you with refinements. For the purpose of this evening's talk my statements are sufficiently accurate. It does not at all matter to our present purpose that 100,000 years ago the figure of the Great Bear was slightly different from what it will be 100,000 years hence, or that the orbit of Jupiter, instead of lying in the plane of the ecliptic, is inclined 1° 18′ 42″ thereto. When you all become so enamoured of the science as to set up for professional astronomers, you will, no doubt, discard my rough and ready methods, and revel in exactitudes in the most approved style.

Should any of you have been wearied by my attempts to translate into the phraseology of every day life, the language of the stars, I hope you will impute the fault to me, and not to this sublime study — so full of interest and beauty — which has numbered among its votaries so many of the best and brightest of mankind, and which, more than any other, lifts our minds from earth towards heaven.

# THE MOON'S ORBIT AROUND THE SUN

By A. B. Turner

WE have been accustomed to think of the moon as belonging entirely to the earth and describing in a year a wavy path with respect to the earth's orbit. Apparently such an orbit for the moon would be concave towards the sun from 1st quarter through full moon to 3rd quarter and convex from 3rd quarter through new moon to 1st quarter, and in some of the older books on astronomy it was incorrectly so represented. (Fig. 1).

FIGURE 1.
Incorrect representation of the moon's motion.

Owing, however, to the fact that the moon's distance from the earth is very small in comparison with the earth's distance from the sun (about $\frac{1}{400}$), and also to the fact that she makes about 13 revolutions around the earth in a year, it is better to consider the moon's path as that of a body describing an orbit around the sun, and which is constantly being slightly disturbed by the pull of the earth. Such a path would always be concave to the sun, but close to the earth's orbit, crossing it twice a month.

An approximate mathematical solution of the problem is obtained by assuming that the earth moves in a circle and that the moon's orbit is a circle in the same plane. Take the sun at

the origin of coördinates, let $a$ be the radius of the orbit of the primary, with period $T$, and $b$ the radius of the orbit of the satellite, with period $T/n$, moving in the same plane. Starting with the satellite in the "new" phase the coördinates of the moon, supposed to be moving direct, will be (Fig. 2)

$$x = a \cos \theta - b \cos n\theta,$$
$$y = a \sin \theta - b \sin n\theta.$$

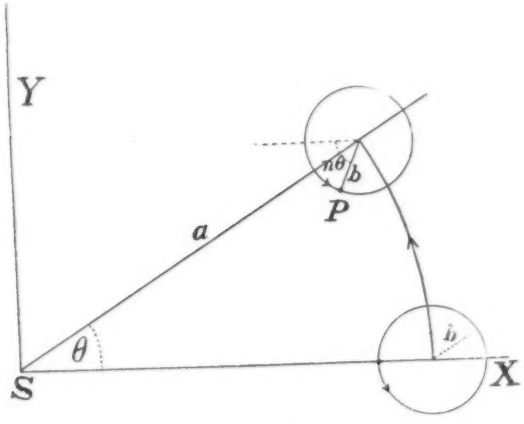


FIGURE 2.
S represents the sun, P the moon.

Now the radius of curvature is given by the formula

$$\rho = \left[1 + \left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}} \Big/ \frac{d^2y}{dx^2}.$$

Differentiating and substituting we find that for any point P of the satellite's path

$$\rho = \frac{(a^2 + n^2 b^2) - 2ab n \cos (n-1)\theta}{ab n (n+1) \cos (n-1)\theta - (a^2 + n^2 b^2)}^{\frac{3}{2}}.$$

Since

$$a^2 + n^2 b^2 > 2abn > 2abn \cos (n-1)\theta,$$

the numerator is always real and positive, and the sign of $\rho$ depends upon the sign of the denominator.

Three cases will be examined.

(1) Suppose $n = 1$.

Then $\rho = -(a - b)$ and the orbit of the satellite is always concave to the sun, that is the moon moves about the sun in a circle of radius $(a - b)$.

(2) If $n = 10$ and $b = \frac{a}{40}$, the denominator of $\rho$

$$= 2{\cdot}75 \cos 9\theta - 1{\cdot}62,$$

which is positive $(+ 1{\cdot}13)$ when $\theta = 0°$, and negative $(- 4{\cdot}37)$ when $9\theta = 180°$. That is, at new moon the moon's orbit is convex to the sun and at full moon it is concave to the sun.

(3) If $n = 13$ and $b = \frac{a}{400}$, we have the denominator of $\rho$

$$= 72{,}800 \cos 12\theta - 162{,}197,$$

which is negative for all values of $\theta$ which are possible. That is, the moon's orbit is always concave towards the sun. When

$$\theta = 0°, \ \rho = - 1{\cdot}620a \text{ (new moon)},$$
$$\theta = 15°, \ \rho = - 0{\cdot}988a \text{ (full moon)}.$$

So that at full moon our satellite is travelling in an orbit having a curvature approximately that of the earth, while at new moon she is travelling in an orbit more than one and one half times as great as the earth's.

THE COLLEGE OF THE CITY OF NEW YORK.

February, 1912.

## MEETINGS OF THE SOCIETY

### At Toronto.

*March 19.*— The meeting was held in the Physics Building, University of Toronto, at 8 p.m., President L. B. Stewart in the chair.

Mr. Robert Bussell, 16 Torrens Avenue, Todmorden, was elected a member of the Society.

The President read a communication from the Harvard College Observatory regarding the discovery of a new star near Theta Geminorum.

Mr. L. Gilchrist, M.A., gave the lecture of the evening on "Some Investigations of the Ether." An account of the discovery and measurement of aberration of a star was given. Then the experiments carried out by Fizeau, Michelson and Morley, Sir Oliver Lodge and others to determine the motion of the ether near a body in motion, and the negative results were presented. Then the lecturer discussed experiments on cathode rays and $\beta$ particles, carried out by Bucherer and others in an endeavor to see if mass changed with velocity. The question of relativity was also considered and the bearing of these experiments on the dependence of the units of time, space and mass on one another.

*April 2.*— The meeting was held in the Rooms of the Society, 198 College Street, at 8 p.m.

In the absence of the President, Mr. John A. Paterson, K.C., was elected chairman for the evening.

Mr. Collins informed the meeting that some members of the Society at Hamilton had observed Nova Geminorum. It had

been seen with the naked eye as a star of about the fifth magnitude. Dr. Chant also reported observations on the Nova. He had seen it through a field glass, power 6, in which it was quite bright. It is now about the sixth magnitude.

Dr. Chant also referred to his observations on the Zodiacal Light. He said that in the early part of March Mr. D. J. Howell had informed him that in the last month he had obtained several good views of the Zodiacal Light, and at Mr. Howell's invitation Dr. Chant accompanied him to his home at Lambton Mills on Saturday the 16th, with the intention of observing this phenomenon.

The sun set at 6.26 and at about 7.45 they went out to observe. The sky was clear, though by midnight it became somewhat overcast. The moon was absent, and they were able to secure a clear view to the west.

The Zodiacal Light was very easily detected — indeed it was almost prominent. At the horizon the precise limits could not be determined, but as nearly as they could judge it stretched about 10° north and the same distance south of the west point.

The column of light, with axis tilted to the south, rose somewhat beyond the Pleiades (*i. e.*, about 70° from the sun). The rounded point appeared to be 2° or 3° north of the Pleiades, this group of stars being just within the boundary of the light. Of course the boundary of the illuminated column was somewhat indefinite, but it could be approximately located by looking at the dark sky to the south for a few minutes and then rapidly looking towards the west.

The Zodiacal Light was decidedly brighter than the Milky Way, but not nearly as bright as the illumination from the city lights to the east.

Under the head of "Notes and Queries," a discussion took place as to how an Arctic explorer would know when he had reached the pole; it was stated that if he were there at the summer solstice, and could observe the sun for twenty-four hours, and see that it was at the same altitude, he would be at the pole. This could roughly be done in practice by setting up a stake and

measuring its shadow. The method of observation by comparison with the data of the Nautical Almanac was also referred to.

The paper of the evening was on "The Dark Structures in the Milky Way." It was forwarded by the Rev. T. E. Espin, F.R.A.S., of Tow Law, Co. Durham, England, and was read by Dr. Chant, and illustrated by some lantern slides. It was exceedingly interesting and will be published in the JOURNAL of the Society. A discussion followed the reading of the paper.

*April 16.*—The meeting was held in the Rooms of the Society, 198 College Street, at 8 p.m.

Mr. Lawrence H. Baldwin, Barrister, Toronto, was elected a member of the Society.

Professor C. A. Chant gave an account of some observations of Nova Geminorum, and also discussed the eclipse of the sun visible in Canada early in the morning of April 17th.

The lecture of the evening was by Mr. W. Park, Brantford, on a "New Astronomical Model," which he had just constructed according to his own plans. A very interesting demonstration of the motions of the earth, sun and moon was given, showing how conditions arise for eclipses; how to know the time at any point of the earth, and other phenomena.

It was moved by Professor C. A. Chant, and seconded by Mr. E. B. Biggar, that having inspected the model devised by Mr. Park for explaining the various phenomena connected with the motions of the sun, earth and moon, the members of the Royal Astronomical Society present, desire to compliment Mr. Park on his ingenuity and enterprise shown in the production of the apparatus; and, believing that the teaching of geography in our schools would be greatly assisted by the use of the instrument, they commend it to the consideration of educational authorities.

It was requested that a copy of the above resolution be sent to the Superintendent of Education for Ontario and to the Chief Inspector for Toronto.

Mr. Park expressed his appreciation of the action of the Society.

*April 30.*—The meeting was held in the Society's Rooms, 198 College Street, President L. B. Stewart occupied the chair.

Among those present was Mr. Andrew Elvins, the Society's oldest member, who will be 89 years old on May 4.

Mr. Bernard Harold Cripps and Rev. C. V. Pilcher were elected members of the Society.

The President explained the condition of the recent eclipse of the sun, to show how it was a total eclipse at one point on the earth and an annular eclipse at other points. He also explained the degree of accuracy to which latitude and longitude may be determined by ships at sea. This information was in answer to queries.

Professor C. A. Chant then gave the lecture of the evening, being "Explanation of the Motions of the Planets, and of the Methods of Finding the Distances of the Fixed Stars."

The illustrating apparatus, planned by Dr. Chant, and made in the University of Toronto work shops, was especially meritorious.

The first piece of apparatus exhibited was a movable lantern slide. In it were two moving glass discs, one bearing a round black dot representing the earth, the other bearing a dot representing Mars. By turning a handle these described circles about the sun, which was at the centre of the earth's orbit but not at the centre of the orbit of Mars. The relative distances of the planets from the sun, as well as their relative periods of revolution were represented with approximate accuracy. A third glass plate, between the others, bore a circle divided into the months of the year.

On turning the handle the phenomena of conjunction, opposition and sidereal and synodic periods were clearly shown; also the relative distances apart of the earth and Mars at successive oppositions, and the fact that the closest oppositions occur every fifteen years.

Another apparatus represented the earth, Mars and the sun. A rod joined the two planets. As they revolved about the sun, by turning a handle; besides opposition and conjunction, the

retrograde motion of Mars was well exhibited. Indeed, this phenomenon was easily illustrated by the first apparatus, though not quite so plainly as in this latter one.

A third apparatus was used to illustrate the method of determining the distance of the fixed stars. A small disc with a sight-hole in it could revolve about a vertical rod at one end of a horizontal bar. This represented the revolution of the earth about the sun. At the other end of the bar was a candle, representing the star whose distance was desired. By looking through the hole, the apparent position of the candle on the opposite wall (the sky), when the disc was made to revolve, was observed and marked. The angle subtended at the observer's eye by the distance between the extreme apparent places (*i. e.*, the parallax of the candle) was measured by a separate simple instrument, consisting of a telescope on a graduated circle. Having obtained this angle an easy calculation gave the distance of the candle from the observer's eye in terms of the radius of the circle described by the hole in the disc.

L. G.

### At Ottawa

*February 29, 8 p.m.*—The fourth meeting of the spring term was held at the Observatory, Mr. J. S. Plaskett presiding.

Dr. Otto Klotz gave the lecture for the evening on "The Moon," to a large audience. He first spoke of the importance of literature, even to the scientist, inasmuch as it dealt with love, honor and all other things which make life worth living, though these things do not exist in number, weight or measure. From this preface he passed to a review of the poetic allusions to the moon quoting extensively from the poets of ancient and modern times. Coleridge's "One bright star within the nether tip" of the moon came in for some merited comment. Dr. Klotz then gave a chronological arrangement of the moon's history. Thrown off from the parent earth by centrifugal force in the earliest times, held at a fixed distance from the earth by gravitation, her day gradually lengthened by tidal retardation, her gases

lost owing to her low gravitational force, the moon has had her cycle of change.

Dr. Klotz then spoke of what can be seen on the moon by the telescope; he explained the phases of the moon, the causes of the tides, the moon as an aid in determining longitude, the annular and total eclipses of the moon, the festivals fixed by the moon's phases. Finally he spoke very emphatically against the absurdity of the belief in the moon as a cause of weather changes.

A series of very fine views of the moon were then shown. Dr. Klotz pointed out upon these the more important physical features.

As the night was clear the meeting adjourned early and those present availed themselves of the opportunity of viewing the moon through the 15-inch telescope.

*March 14, 3 p.m.*— The fifth meeting of the spring term was held in the Observatory, Mr. J. S. Plaskett presiding.

Mr. F. B. Reid, D.L.S., gave a very interesting paper on "Precise Levelling in Canada."

The paper dealt chiefly with the methods employed and the territory covered by the Geodetic Survey, but touched briefly on the precise levelling done by other branches of the Dominion Government and by the railways. The demand for precise levelling was pointed out and a reference made to the discrepancies existing in some of the elevations now given for different points in Canada.

Mr. Reid described in detail how the Geodetic Survey carried on their work. The levels were usually carried along railway tracks, the advantages and disadvantages of this being discussed. The bench marks from which the survey was begun, the extensions along the different lines, the scheme of extending first trunk and then branch lines, the connections with other lines of levels, the closing error of different circuits and the proposed extensions for the coming year were then discussed. Other subjects fully treated were:— Bench marks, under which the construction of concrete piers was described; the instruments for

carrying on the work; field operations; limits of error allowed; and the finding of mean sea level.

The reading of the paper evoked an interesting and profitable discussion in which Dr. King, Dr. Dawson, Mr. James White, Mr. McArthur and Mr. Nelles took part.

The paper in full will appear in the next issue of the JOURNAL.

*March 28, 8 p.m.*— The sixth meeting of the spring term was held in the Dominion Observatory, Mr. J. S. Plaskett presiding.

Mr. T. H. Parker, M.A., read a paper entitled "The Heavens through a Field Glass." The object of this paper was in part to meet the objections of those who considered the evening popular lectures of the Society too technical. In his treatment of the subject Mr. Parker certainly met this objection, as the paper was entirely free from technical terms, and was such that anyone having even the slightest interest in the stars could easily follow it.

The paper dealt mainly with the finding of the constellations in the heavens, the description of each and a recital of the legendary myths in connection. As Mr. Parker dealt with the constellations visible at the time of his paper he began with Orion, the most splendid and most striking of all. Using Orion as a basis of reference he then discussed the constellations in the neighborhood, and in many cases dealt with individual stars and occasionally referred to striking objects not known to the ancients but notable to modern astronomers, such as the nebula in Orion's sword.

One of the strong points of Mr. Parker's paper was the way in which he showed how the constellations could be found by the novice in astronomy, using in this connection a printed star map distributed among the audience, and many lantern slides.

A goodly number were present to hear the lecture. After adjournment many availed themselves of the opportunity of observing the stars through the telescope.

*April 11, 3 p.m.*— The seventh meeting of the spring term was held at the Observatory, Mr. J. S. Plaskett presiding.

Short papers were given as follows:

Mr. R. J. McDiarmid, M.Sc., on "Parallax Determination," outlined the three important methods of finding parallax of fixed stars by means of the heliometer, the photographic plate used with a large telescope and the meridian circle. He discussed in each case the results obtained and the probable errors.

Dr. R. E. DeLury described a new method of chemical analysis devised by Professor J. J. Thomson, of Cambridge, Eng., for the determination of the gases present in a vacuum tube through which an electric discharge is passing; the positive rays passing through a small tube in the cathode are repelled by magnetic and electrical fields in such a way that the rays for each combination of particle and charge produce a parabolic image on a photographic plate. From these images the masses and charges of the particles may be determined and in this way many interesting classes of elements and compounds were found in vacuum tubes of different gases. For example, in a methane tube four compounds of carbon and hydrogen were found besides carbon itself ($CH$, $CH_2$, $CH_3$, $CH_4$). In atmospheric nitrogen, argon with two different charges was found. In other tubes oxygen and nitrogen were found in many different combinations of atom and charge.

Mr. C. C. Smith, B.A., gave a paper on "Star Collisions," which dealt chiefly with the theories of Professor A. W. Bickerton, of New Zealand, to account for the phenomena of "Novæ" or new stars, on the assumption of a grazing collision of two stars. The chief points of the theory were explained and arguments in favor of and against it were discussed.

Mr. W. A. Dier read a paper on "Wireless Telegraphy." He confined his attention to present methods of wireless communication in which no induction coil is used but instead three circuits of direct currents. After explaining the working of the apparatus by means of a diagram, Mr. Dier gave some interesting facts relating to its use.

In the absence of Mr. F. A. McDiarmid, B.A., who was to speak on "Variation in Latitude," and Mr. R. M. Motherwell, M.A., who was to speak on "Comets," Mr. W. E. Harper, M.A., gave a short talk on "Calcium Cloud in Spectroscopic Binaries." Mr. Harper gave the results of work of men of different observatories showing that certain lines in the spectrum (the absorption lines due to calcium vapor) give velocities for star systems different from other lines. The theory of a calcium cloud stationary with regard to the universe, as also the idea of a nebulous calcium veil surrounding the star system itself was advanced but as yet it was too early to speak positively.

After this a discussion of the many interesting points brought up by the papers took place.

*April 25, 8 p.m.*— The eighth meeting of the spring term was held at the Observatory, Mr. J. S. Plaskett presiding.

The lecturer of the evening was Sir Joseph Pope, K.C.M.G., who spoke on "The Planet Jupiter."

Sir Joseph first stated four motions of the heavenly bodies which might be noted by any one without the aid of instruments *viz.*, (1) That apparent diurnal motion of all heavenly bodies about the earth. (2) The motion of the moon among the stars, or the revolution of the moon about the earth. (3) The motion of the sun among the stars, or the revolution of the earth about the sun; and (4) The variation of the points of rising and setting of the sun according to the seasons. To these might be added a fifth requiring a little more care to detect, *viz.*, the motion of some "stars" among the others and the "wandering" character of these motions. Such stars, or planets, were then named and the reasons for their erratic motions given.

The planet Jupiter was then described in particular.

The character of its light, the times of the year when it is visible, its oppositions, its size, shape, specific gravity, appearance through the telescope and its reflective power were carefully described. The interesting discovery of its moons and the effect of the discovery in establishing the truth of the Copernican theory were given.

After the lecture a vote of thanks, moved by Dr. Otto Klotz seconded by Professor James Mills was heartily endorsed by the large audience present.

C. E.

AT HAMILTON

*March 22, 1912.*— A regular meeting of this Centre was held this evening, the local president, Mr. Wm. Bruce, in the chair.

The president read a short note from Mr. Abbott describing Nova Geminorum.

Mr. J. R. Collins, of Toronto, before starting his lecture, made a diagram showing the position of the new star.

Mr Collins' subject was "Our Earth a Planet." He described the relative sizes of the various bodies of the solar system, their places and motions, the earth's place among them and the apparent intricacy of motion of earth and planet, as such an outlook in the heavens involved.

At the close a hearty vote of thanks was voted the lecturer for an address which had been much enjoyed by all.

The new star was visible to the naked eye from the steps of the library after the meeting.

*April 12.*—Mr. Wm. Bruce, the local president, occupied the chair at the regular meeting held this evening in the lecture room at the Public Library Building.

The preliminary business having been disposed of, Mr. J. Patterson, B.A., of the Meteorological Office staff in Toronto, delivered a lecture entitled "Our Knowledge of the Air in Free Space as Determined from Kite and Balloon Ascents."

The lecturer referred to Astronomy and Meteorology as being twin sciences, for not only were they akin but they were also of equally great age; for it is probable that the first things observed in nature by early man were the aspects of the heavens and the changes in the weather.

However, there was a great difference between the twins in the exactness of the knowledge attained, for while the astronomer could predict years and centuries in advance, it was with

fear and trembling the meteorologist ventured beyond one or two days. When, however, the time comes that he can predict for a longer period, then would more benefit accrue from meteorology than from any other science. Already to some extent floods may be, if not avoided, somewhat provided against, shipping disasters avoided owing to warnings being given in time of impending storms; and also in the knowledge attained as to the avoidance of the track of the centre of cyclones at sea.

The golden age will come when the farmer will know whether to sow early or late; for a wet season or a dry one; when to expect frosts, etc.

When the mariner will know exactly what to expect during the coming voyage, and many other similar good things.

The conditions of the air in space were investigated by three means.

First, by the aid of kites which were limited as to height.

Second, by balloons, which could be sub-divided into three classes, (*a*) When a man was a passenger and made the necessary observations, but this again was limited by the height to which a man could go, namely in the neighborhood of five or six miles. (*b*) Captive balloons, with self-recording instruments, this again was limited to about one mile. (*c*) Free balloons in which the chance was taken as to ever seeing either balloon or records.

Third, by aeroplanes, which was as yet untried.

The lecturer described the flying of the kites, the pull exerted in various winds, the apparatus employed for letting out and pulling in the kites, the means of relieving the excessive pressure upon the receiving drum caused by the pull upon the wire.

Then followed a description of the recording instruments and the records obtained, the greatest flights and how attained, the successes and failures of the Toronto station.

The record height attained, to obtain which eight kites were used, was 22,000 feet.

With balloons much the same procedure was gone through; each case containing the instruments was carried some distance

below the balloon, to be free from any influence which the latter might exert upon it.

The carrier was buoyed up by small ballons so that no injury should be done by too rapid a fall, and a tag was attached asking the finder to communicate with the Office in Toronto, a reward of $2.50 being offered.

The mysterious isothermal layer was then described, that wonderful layer beyond which no investigation has yet reached, beginning at about eight miles and continuing as far as yet gauged up to sixteen miles above the earth's surface.

Some of the strange facts ascertained were mentioned *viz.*, that the isothermal layer was lower and warmer in winter than in summer, that it was higher and colder over the equator than at the pole, and that the surface temperature seemed to have but little influence.

For example when last July we were luxuriating at over 100° the isothermal layer registered far below zero centigrade; in other words, while variation at the surface during the year was above 120° F. the layer did not vary over 20°.

At the close a very hearty vote of thanks was tendered the lecturer for his most interesting address.

T. H. W.

### At Peterborough

*March 19.*—The regular meeting was held in the Physical Laboratory of the Collegiate Institute, Mr. H. O. Fisk, C.E., President, in the chair.

Mr. J. A. Seger and Mr. H. Carveth gave reports of observations with the Stratton and Stupart telescopes, after which Mr. H. B. Collier, of Toronto, former President, gave an interesting lecture on "Astronomy *vs.* Astrology." The lecturer treated his subject in a very interesting and helpful manner.

*April 1.*—The regular meeting was held; Mr. H. O. Fisk in the chair.

Mr. S. J. Keyes, B.A., B.Paed., of the Peterborough Nor-

mal School, gave an interesting account of his observations on the moon with the Stratton telescope.

Mr. H. Carveth reported observations on the planet Mars with the Stupart telescope.

Mr. Fred. L. Roy, of the Roy Studio, was elected a member of the Society.

The chairman introduced Mr. J. R. Collins, of Toronto, who gave a very entertaining lecture on "Our Earth a Planet." Mr. Collins was accorded a vote of thanks for his interesting lecture.

*April 22.* — There was an exceptionally large attendance at the meeting which was held in the Collegiate Institute.

After the regular business had been transacted, Mr. Carveth reported his observation with the Toronto telescope and Dr. Marsh spoke of the eclipse of the sun, April 17th. Some photographs of which were thrown on the screen.

The feature of the evening was the lecture on "Mars: Is It Inhabited?" by Mr. T. C. Elliott. The subject was treated in considerable detail and was well illustrated by excellent slides.

D. B. M.

## NOTES FROM THE METEOROLOGICAL SERVICE

### Summary Report of the Weather in Canada

#### February

*Temperature.*— In extreme southwestern British Columbia and on Vancouver Island the mean temperature for February did not differ greatly from normal, but in the southern interior of the province there was a positive departure of from 3° to 6°, and along the Upper Fraser of from 6° to 9°.

At Banff the normal mean for the month was exceeded by less than 6°, but over the greater part of Alberta there was a positive departure from normal, of from 10° to 13°.

In Saskatchewan and Manitoba also the month was much warmer than usual, the mean temperatures exceeding the normal by from 6° to 9°. For the first ten days, however, the minimum temperatures were very low, ranging as far as 38° below zero on the 8th.

Except in the district of Thunder Bay, the month was colder than usual throughout the Province of Ontario, the negative departure from normal ranging from a fraction of a degree in Algoma, to 8° or 9° in the vicinity of Lake Erie. Temperatures below zero were of frequent occurrence during the first fourteen days, and in the Georgian Bay counties were very low, minima ranging between 30° and 40° below, on the 9th and 10th.

From Montreal as far as Quebec City, mean temperatures were 1° or 2° lower than the normal, but from Quebec eastwards, the deviation was positive, increasing to from 5° to 7° in the Gulf of St. Lawrence.

In northeastern New Brunswick the mean temperature for the month ranged from 3° to 6° above normal, while in the southern part of the province, and in Nova Scotia and Prince Edward Island there was little deviation from normal.

*Precipitation.*— Throughout British Columbia the amount of precipitation was less than average, except for local excess in Central Vancouver Island and on the Lower Fraser River.

In many portions of the Western Provinces there was only a flurry of snow during the month, while in most of the other districts the fall was large enough to measure on three days only.

Over the greater part of Ontario there was a general and pronounced deficiency in the precipitation for the month, except along the Upper St. Lawrence and Upper Ottawa, where the usual amount was more nearly approached.

At Montreal, in the southwestern counties of Quebec, and at Father Point there was a small excess, but over the remainder of the province there was a deficiency which in most cases was equivalent to 20 per cent. of the normal amount.

In northern New Brunswick the deficiency was very small, but elsewhere in the Maritime Provinces from 30 per cent. to 50 per cent. less than the normal was recorded.

## March

*Temperature.*— The month of March was unusually cold over the greater part of the Dominion, with the largest negative departures from average in southern Saskatchewan and southern Ontario. In southern British Columbia mean temperatures for the month ranged from a fraction of a degree to about 3° below average, while in northen districts of the province it was above average, the positive departure at Dawson reaching 9°.

In southern Saskatchewan, southwestern Manitoba and southeastern Alberta mean temperatures ranged from 5° to 8° below normal, but elsewhere in the Western Provinces the negative departure was only from a fraction of a degree to 4°, except locally, where positive departures were recorded.

In the peninsula of Ontario the mean for the month ranged from 4° to 8° below average, while in the northern districts of the province the negative departure was from 4° to 5°.

In western Quebec the average for the month fell about 4° below normal, while in the gulf districts the negative departure was only from 1° to 2°.

Mean temperatures in the Maritime Provinces were nowhere much below normal, negative departures ranging from a fraction of a degree to 2°.

*Precipitation.*— In British Columbia and the Western Provinces the precipitation for March was only from 10 per cent. to 50 per cent. of the normal amount, except locally in southwestern Manitoba and northern Saskatchewan, where the normal was reached or slightly exceeded.

In the Peninsula of Ontario and on the Lower Ottawa the precipitation for the month was from 60 per cent. to 90 per cent. of the normal for the month, while in northern districts only from 25 per cent. to 65 per cent of the normal amount was recorded.

In Quebec only about one-half of the normal fall was registered, except in the Gulf districts, where there was an excess.

In northern New Brunswick and eastern Nova Scotia the fall was from 15 per cent to 20 per cent. in excess of the normal amount for the month, while in the southern districts of the former province and in western Nova Scotia only about two-thirds of the normal was recorded.

## Temperatures for February and March, 1912

| Station | February | | March | |
|---|---|---|---|---|
| | Highest | Lowest | Highest | Lowest |
| *Yukon* | | | | |
| Dawson | | | | |
| *British Columbia* | | | | |
| Atlin | 42 | −6 | 46 | −13 |
| Agassiz | 54 | 28 | 65 | 26 |
| Barkerville | 42 | −5 | 50 | −9 |
| Kamloops | 49 | 9 | 66 | 8 |
| New Westminster | 51 | 25 | 63 | 23 |
| Prince Rupert | 62 | 25 | 60 | 25 |
| Vancouver | 53 | 25 | 56 | 26 |
| Victoria | 54 | 28 | 60 | 27 |
| *Western Provinces* | | | | |
| Battleford | 37 | −28 | 53 | −27 |
| Broadview | | | | |
| Calgary | 49 | −7 | 60 | −16 |
| Carman | | | | |
| Edmonton | 50 | −20 | 58 | −17 |
| Medicine Hat | 47 | −15 | 61 | −18 |
| Minnedosa | 34 | −28 | 38 | −26 |
| Moose Jaw | 38 | −32 | 51 | −25 |
| Oakbank | 34 | −30 | 36 | −25 |
| Portage la Prairie | | | 43 | −16 |
| Prince Albert | 41 | −31 | 53 | −27 |
| Qu'Appelle | 37 | −26 | 42 | −28 |
| Regina | 33 | −27 | 44 | −29 |
| Swift Current | 36 | −22 | 50 | −22 |
| Winnipeg | 38 | −26 | 41 | −18 |
| *Ontario* | | | | |
| Agincourt | 39 | −24 | 45 | −1 |
| Aurora | 40 | −26 | 47 | −14 |
| Bancroft | 43 | −35 | 45 | −33 |
| Barrie | | | | |
| Beatrice | 42 | −36 | 44 | −18 |
| Birnam | 40 | −24 | 45 | −7 |
| Bloomfield | 37 | −25 | 42 | −8 |
| Brantford | 42 | −16 | 50 | 0 |
| Bruce Mines | 44 | −42 | 44 | −21 |
| Chatham | 45 | −18 | 55 | 3 |
| Clinton | 47 | −25 | 42 | −12 |
| Cottam | 42 | 25 | 60 | −2 |
| Gravenhurst | 41 | 41 | 48 | −24 |
| Guelph | 39 | 21 | 47 | −4 |
| Haliburton | 43 | 40 | 47 | −29 |
| Hamilton | 43 | −14 | | |
| Huntsville | 37 | −36 | 46 | −27 |
| Kenora | 29 | 32 | 34 | −24 |
| Kinmount | | | 45 | |
| Kingston | 39 | −24 | 45 | −7 |
| Lakefield | 44 | −28 | 52 | −13 |
| London | 43 | −20 | 52 | −1 |
| Lucknow | 41 | −32 | 42 | −16 |
| Madoc | 37 | −27 | 48 | −17 |
| Midland | | | | |
| North Gower | | | | |
| Otonabee | | | | |
| Ottawa | 35 | −23 | 44 | −17 |
| Owen Sound | 40 | | | |
| Paris | 42 | −17 | 50 | −5 |
| Parry Sound | 43 | −33 | 48 | −18 |
| Peterboro' | 39 | −30 | 49 | −15 |
| Port Arthur | 36 | −27 | 45 | −14 |
| Port Burwell | 43 | −19 | 46 | −3 |
| Port Dover | 40 | −19 | 47 | 0 |
| Port Stanley | 40 | −26 | 45 | 1 |
| Ronville | 45 | −42 | 51 | −29 |
| Sarnia | 48 | −24 | | |
| Southampton | 38 | −34 | 44 | −21 |
| Stonecliffe | 37 | −35 | 45 | −30 |
| Stony Creek | 43 | −17 | 49 | 1 |
| Stratford | | | | |
| Toronto | 46 | −19 | 49 | 4 |
| Uxbridge | 39 | −26 | 43 | −15 |
| Wallaceburg | 44 | −22 | 49 | −2 |
| Welland | 42 | −6 | 50 | 1 |
| White River | 34 | −54 | 39 | −39 |
| *Quebec* | | | | |
| Brome | 42 | −22 | 47 | −27 |
| Father Point | 39 | −12 | 38 | −3 |
| Montreal | 36 | −18 | 42 | −7 |
| Quebec | 36 | 19 | 44 | −11 |
| Sherbrooke | 39 | −17 | 48 | −25 |
| *Maritime Provinces* | | | | |
| Charlottetown | 40 | −14 | 48 | −10 |
| Chatham | 46 | −21 | 48 | −11 |
| Dalhousie | 40 | −15 | 42 | −15 |
| Fredericton | 45 | −25 | 49 | −13 |
| Halifax | 44 | −12 | 50 | 0 |
| Moncton | 42 | 18 | 53 | −8 |
| St. John | 44 | −12 | 49 | 3 |
| St. Stephen | 48 | −29 | 51 | −21 |
| Sussex | 46 | 24 | 55 | −15 |
| Sydney | 41 | 13 | 51 | −2 |
| Yarmouth | 46 | 2 | 50 | 3 |

## Earthquake Records by the Milne Seismograph

### TORONTO

R. F. Stupart, Director.

P.T. = Preliminary Tremors. L.W. = Large Waves. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

| No. | Date 1912 | P.T Comm. | L.W. Comm. | Max. | End. | Max. Amp. | Durat. | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | h m | h m | h m | h m | mm. | h m | |
| 1080 | Feb. 19 | 23 12·5 | | 23 12·8 | 23 26·9 | 0·5 | 0 14·5 | |
| 1081 | " 21 | 8 2·8? | 8 15·0 | 8 15·0 | 8 25·0 | 0·4 | 0 22·2 | ATs at commencement. |
| | | V 8 8·6 | | | | | | |
| 1082 | Mar. 11 | 10 31·2 | V 10 35·9 | 10 37·9 | 11 44·2 | 3·0 | 1 13·0 | First measurement rather doubtful. |
| | | 10 34·0 | W 10 37·1 | | | | | |
| 1083 | " 25 | 5 20·3 | | | 5 21·5 | 0·05 | 0 1·2 | By slight thickenings. |

Period 14·7 seconds. 1 mm. = 0″·64.

### VICTORIA, B. C.

E. B. Reed, Superintendent.

| No. | Date 1912 | P.T. Comm. | L.W. Comm. | Max. | End | Max. Amp. | Durat. | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | h m | h m | h m | h m | mm. | h m | |
| 1095 | Feb. 19 | 22 53·1 | | 22 54·3 | 23 12·6 | 1·2 | 0 19·5 | |
| 1096 | Mar. 11 | 10 18·3 | 10 20·1 | 10 20·4 | 11 29·0 | 12·5 | 1 11·7 | Rapid vibs. earthquake probably off Vancouver Island. |
| 1097 | " 25 | 5 14·1 | | | 5 16·8 | 0·05 | 0 2·7 | Slight thickenings. |

Period 15 seconds. 1 mm. = 0″·76

J. Y.

## MAGNETIC OBSERVATIONS

During the months of February and March the magnets at Agincourt were unusually quiet, and no disturbances worthy of note were recorded.

An earth inductor was added to the equipment of the observatory in February and it is hoped comparisons with former instruments for obtaining Inclinations will soon be completed and the results available for comparative purposes.

Declination

| Month | Mean of Month | Max. | Date | Min. | Date | Monthly Range | Amplitudes—Mean Daily From hourly readings | Amplitudes—Mean Daily From Means of Extremes |
|---|---|---|---|---|---|---|---|---|
| 1912 | ° ′ | ° ′ | | ° ′ | | ° ′ | ′ | ′ |
| Feb. | 6 12·3 | 6 21·7 | 13 | 5 56·9 | 16 | 0 24·8 | 5·2 | 9·5 |
| Mar. | 6 12·6 | 6 24·6 | 29 | 5 50·7 | 7 | 0 33·9 | 9·4 | 12·4 |

Bifilar—C.G.S. Units

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Feb. | ·16188 | ·16208 | 1 | ·16142 | 26 | ·00066 | ·00015 | ·00029 |
| Mar. | ·16181 | ·16214 | 8 | ·16137 | 29 | ·00077 | ·00029 | ·00041 |

Inclination

| Month | Mean Dover No. 209 | Mean Earth Inductor |
|---|---|---|
| | ° ′ | ° ′ |
| February | 74 39·8 | |
| March | 74 39·9 | 74 40·7 |

## ASTRONOMICAL NOTES

A Resisting Medium in Space.— One or two comets besides Encke's have been suspected of showing signs of the effect of resistance, but the evidence is of a somewhat indefinite and contradictory character. I do not know whether one may venture to attribute the outstanding discrepancy of two days between the predicted and observed times of return to perihelion of Halley's Comet, to a *retarding* effect of the resisting medium upon this *retrograde* comet, just as the *direct* moving comet of Encke is *accelerated*, but, perhaps, the difference of two days is too great to be thus accounted for. Halley's Comet, however, moves over so extended an orbit that it is not, perhaps, unreasonable to expect a greater quantitative effect on its motion, though taking into account the difference in their periodic times, 3½ years and 76 years, there is not so much difference after all. But I believe the earlier returns show no such difference between predicted and recorded dates of perihelion passage of Halley's Comet, so it is, perhaps, rather rash to generalise upon a single occurrence.

The extinction of light in the celestial spaces, due either to the imperfect transparency of the ether or to the presence of cosmical dust and also of *dark bodies*, has been considered by Professor Turner, Dr. Seeliger, Professor Kapteyn and others whilst Professor See has drawn attention to the probable effect of such material upon the aggregation of the Milky Way into clusters and the condensation of these latter into more or less globular form. Though these matters can only be mentioned

here, yet on their further consideration will depend much of the future progress of our science in the interpretation of the wonders of the heavens.— F. W. HENKEL, *Journal British Astronomical Association*, Vol. XXII., No. 1.

SPIRAL NEBULÆ.— Professor Max. Wolf discusses the question of determining the parallax of some of the greater spiral nebulæ by comparing the dimensions of the holes or void spaces in them with those of void spaces in the Milky Way. He has measured several of these void spaces in the nebulæ, and finds remarkable regularity in regard of the ratio of length to breadth.— *Astronomische Nachrichten*, No. 4549.

THE CONSTITUTION OF THE SOLAR CORONA. I.: PROTOFLUORINE.— In a previous paper the nebular spectrum was discussed from the point of view of a definite theory of atomic constitution, and it was shown that there is reason for the belief that most of lines of this spectrum may be due to a substance which was called nebulium, a more elementary form of matter than any yet discovered on the earth. The theory in question involves also the existence of other simple forms, and an application of the method of the last paper has indicated that the free vibrations of one of these forms, which was called protofluorine when the theory was first introduced, do not appear to be represented in the nebular spectrum. In these circumstances it is natural, in the search for a verification of its existence, to turn our attention to the coronal spectrum, where matter is also believed to give evidence of its most elementary forms. The paper takes up the examination of this spectrum on the previous lines, and considerable evidence is adduced to show that this substance is capable of giving rise to a large number of the coronal lines.— DR. J. W. NICHOLSON, *Monthly Notices*, R.A.S., Vol. LXXII., No. 2.

THE CONSTITUTION OF THE RING NEBULA IN LYRA (N.G.C. 6720).— In a paper on "The Spectrum of Nebulium," Dr. Nicholson showed that this hypothetical substance could give an account of all unidentified nebula lines tabulated by

Wright, except two. On these two, Dr. Max Wolf threw light in a recent publication (Sitz. der Heidel. Akad., Jahrgang, 1911, Abhand. 27). In the ring nebula in Lyra, Dr. Wolf finds that the central dark space of the nebula, after a long exposure, affects the plate, and that the radiation of wave-length 4686, arises solely from this space, and not from the bright ring. Also that the maximum emission for the wave-length 3729 occurs towards the outer edge of the bright ring, although extending more faintly throughout the ring itself.

When this evidence is considered together with the writer's paper, it is evident that nebulium can account for all the connected unknown lines of Wright's table without exception, and the view that they are actually caused by it is considerably strengthened. As to the nature of the substances which lie in the dark space and perhaps beyond the bright ring of the Ring Nebula, it is very difficult to conjecture, for each is not sufficiently luminous to show more than its strongest line. Apparently, however, the interior substance may be denser than either hydrogen or nebulium, and it may be a terrestrial element formed by combination from the more primary forms. Mr. C. P. Butler, in the discussion on the writer's paper, also stated that he had noted peculiarities in this line 4686, and that there was reason for believing that it could be produced in the laboratory. — *Monthly Notices*, R. A. S., January, 1912.

Systematic Motions of the Stars.— Professor Lewis Boss, before the Astronomical and Astrophysical Society of America, December 29, 1911, remarks:—

"Seven years ago Professor Kapteyn, at the Scientific Congress of the St. Louis Exposition, introduced his now well-known hypothesis that the visible universe consists of two great intermingling streams moving in opposite directions. The direction of one he called the "vertex," which he fixed at R. A. $6^h\ 4^m$, Decl. + 13°. Quite recently Eddington of the Greenwich Observatory, with the same hypothesis, and using the proper motions of the "Preliminary General Catalogue," found for this vertex: R. A. $6^h\ 16^m$, Decl. + 12°.

In 1907 Schwarzschild advanced the hypothesis that a systematic arrangement of the proper motions leads to an ellipsoidal arrangement of distribution and he endeavored to show that the proper motions of Groombridge's Catalogue are as well represented as they are by the hyyothesis of two streams.

By a method entirely different from that employed by either of the two investigators, the department found nearly a year ago that when its proper motions were compared in a manner to bring out this systematic arrangement, it was seen that if all the actual motions of the stars in any considerable area of sky were brought to a common origin (freed from their solar parallactic motions) the figures so constructed would have an elliptic outline, which turned out to be different presentations of an ellipsoidal figure of which, if the major axis be taken as 7, the two minor axes would be 4. The major axes of all the figures points very nearly towards the vertex of Kapteyn; this point was found to be in R. A. $6^h$ $15^m$ and Decl. + 7°. Moreover, these ellipsoids have well-marked nuclei composed chiefly of stars of types *B* and *A*. This fact would require a third stream to complete the "two stream" hypothesis, as some of the supporters of the latter have already perceived.

The speaker presented considerations in support of his belief that this ellipsoidal arrangement of the star-motions in space would be reduced to a simple and natural explanation, if we suppose that the stars had been originally formed in nebulas and repelled from the regions of their formation with a tendency to be impelled by some kind of polarity 50 to 75 per cent. faster in the direction of the major axis of the ellipsoid than in the direction at right angles to that. This hypothesis also fits in well with the undoubted phenomenon of acceleration of a star's motion with age. — *Popular Astronomy*, April, 1912.

Favorable Future Oppositions of Mars.— Interesting diagrams are given by Baldet in the *Bulletin* de la Société Astronomique de France for February, 1912, showing the relative disk of Mars, and hence the favorable or unfavorable character of the opposition, till the year 1950. All oppositions till 1922

will be rather unfavorable, that of 1916 showing a disk only one-fifth of that at the most favorable oppositions. In August, 1924, however, will occur an opposition of maximum brilliancy, easily the best during this half century. — *Publication Astronomical Society of the Pacific*, No. 141.

Reported Discovery of a New Comet.— We learn, from *The Daily Mail* of May 14, that the following telegram has been received at the Greenwich Observatory:— "A comet-like object with a tail has been observed by Mr. Hansen at Praestoe, Denmark. It is of intense magnitude, and its position, given on May 10, at two o'clock, was R.A. $20^{h}$ $53^{m}$ $20^{s}$; Decl. 31° 24′ N."

Probably the first statement of the second sentence should read, "It is of *the tenth* magnitude," for we are told that it is not visible to the naked eye. The position given lies about halfway between $\zeta$ and $\epsilon$ Cygni, and is on the meridian at about 5 a.m.; that is to say, it is above our horizon during all the hours of darkness.

The origin of the above telegram is not stated, and, so far, we have received no intimation of the discovery from the Kiel Centralstelle.— *Nature*, No. 2220.

J. R. C.

## NOTES AND QUERIES

**Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.**

### Query

It was stated that the new star in Gemini was at first of the type F 5 G. Will you please explain this?—C. W. W.

### Answer

To ordinary observation the stars show different colors—blue-white, white, yellow, red, etc.—and we are not surprised to find that when their light is analysed by the spectroscope widely-varying spectra are obtained.

Secchi, of Rome, examined the spectra of more than 4000 stars, and divided them into four distinct types. These are, briefly, as follows:—

Type I.—The spectrum is especially rich in violet rays, and exhibits broad, intense, dark bands across it, due to absorption produced by hydrogen in the star's outer envelopes. These stars are white or blue-white, *e. g.*, Sirius, Vega.

Type II.—The spectrum shows an abundance of narrow dark lines, due to absorption by metallic vapors in the star's atmosphere. These stars are yellow, *e. g.*, our sun, Capella.

Type III.—The spectrum exhibits a number of sets of flutings of dark lines, close together at the end towards the blue and spreading apart at the other end. The stars of this type are red, *e. g.*, Betelgeuse.

Type IV.—Flutings as in Type III., but with the spacing of the lines reversed. These stars are of a deep red, and there are no bright examples.

A fifth type is usually added, containing stars whose spectra exhibit bright lines as well as dark ones.

At the Harvard Observatory after examining the spectra of over 10,000 stars, a much more detailed classification was possible. These classes were denoted by the letters of the alphabet, beginning at A and going up to Q. Continued research has led to a slight modification, and the main divisions are now B, A, F, G, K, M, the class B being put first as there is now reason to believe that the stars included in it are younger in their course of development than those in Class A.

The characteristics of these types are:—

B.—Sometimes called "Helium" or "Orion" type. Lines due to helium more prominent than those due to hydrogen. Typical stars: Epsilon, Zeta, Delta, Orionis.

A.—Hydrogen lines very prominent. Secchi's Type I. Typical stars: Sirius, Vega.

F.—Intermediate between Secchi's I. and II. Types. Hydrogen about half as strong as in A, and numerous fine lines present. Typical star: Alpha Carinæ.

G.—Secchi's Type II. Hydrogen lines about one-fifth as intense as in A. Calcium H and K lines and the G group conspicuous. Typical stars: our sun, Capella.

K.—Intermediate between Secchi's II. and III. Hydrogen lines one-twelfth as intense as in Sirius. Calcium K line at its maximum strength. Typical star: Arcturus; its spectrum resembles that of a sun-spot.

M.—Chiefly Secchi's Type III. Spectrum banded. In some stars hydrogen lines are seen very faint, while in others they are bright. Examples: Betelgeuse (Ma), Gamma Crucis (Mb), Mira Ceti (Md).

In addition to these, Class O corresponds to Secchi's Type V. and it is put before A, while Class N corresponds to Secchi's Type IV. and it follows M. There are few stars in these classes. Class F 5 G means that the star is intermediate between F

and G at five-tenth of the interval from F onward to G. Procyon is of this class, while Aldebaran is of Class K 5 M, *i. e.*, half-way between classes K and M.

The above is a very bare outline of the classification of stars according to their spectra. The subject is an intricate one, but there is little doubt that by interpreting the spectrum of a star we can determine how far on it is in its life history.

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## THE DISCOVERER OF THE *NOVA* IN GEMINI

We are always interested to learn how a discovery was made and also to obtain information regarding the discoverer, especially if he is an amateur. In *Popular Astronomy* for May is a letter written by J. Rode Jacobsen, of Chicago, giving a pleasing account of the Norwegian astronomer who detected the latest *nova*, and which is printed below :—

The Norwegian astronomer, Mr. Sigurd Enebo, has a very simple observatory at Domaas, Norway. From here he discovered, on the night of March 12-13, the Nova Geminorum, which has made his name famous. Singularly enough, Herschel, on this same date, in 1781 discovered the planet Uranus — also in the constellation Gemini.

Mr. Enebo's "observatory" is of the home-made variety, and consists simply of a square hole dug in the ground, down to which he descends to watch the stars on every clear night. In the day-time it is covered up by a trap door, and resembles an old abandoned well much more than an astronomical observatory. Whether he received the idea for his "observatory" from Tycho Brahe's "Uraniborg" or not shall be left unsaid; but in his circumstances it has proved to be practical, and he certainly has made good use of it.

Sigurd Enebo was born in 1866 at Lesjeskogen, Norway, where also is situated his farm Domaas, (which means "dome-ridge" — a fitting name indeed for the home of an astronomer, although this one does not yet boast of any dome-bedecked observatory). He chose for his profession that of a country school teacher, and for several years he taught school during the day, and cultivated his passion, astronomy, during the night. In his spare moments he studied, without any outside help, the higher mathematics and the French language, — no doubt in order to study the "Mécanique Céleste" in the original tongue.

Mr. Enebo is, therefore, a self-made and self-taught astronomer. His specialty is the watching and the recording of variable stars, and he is also a skilful computer of cometary elements and orbits. Several valuable essays and articles

from his pen have appeared in the daily as well as the astronomical papers and magazines of Europe.

In 1906 he captured the "Lindemann's Prize" of the "Astronomische Gesellschaft," and since 1908 he has received a yearly stipend from the Norwegian Government, in order that he may devote his entire time to astronomy.

It is to be hoped that the necessary funds for the erection of a modern equipped observatory will soon be obtained by Mr. Enebo, so that the science of astronomy may be benefited by the observations of this zealous observer, made under more favorable circumstances.

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## CONTRIBUTIONS FROM EXAMINATIONS

**Soon after the sun enters Aries the phenomena of the spring, examinations begin to be observed; and the contributions to our scientific knowledge which some of the candidates make are remarkable. I give below some interesting bits of information which have come to me :—**

First of Aries -- is the time when from the earth as it moves in its orbit we can observe the sun and it seems to reach the star called Aries. At that time of the year spring begins.

On it [the sun] there are many peculiar markings. Sometimes dark spots known as sun-dogs appear.

If the sun moved along the declination of the celestial equator it would always cut the meridian in regular points.

The sun is a huge glowing mass millions of miles away from the earth and as many times as large as the earth. It is a great feature of astronomical research as it lights and sustains all our organic kingdom.

The stars in summer differ from those in winter owing to the different refraction of the light from the sun upon them.

As seen through a very large telescope it [the moon] is a disappointment as only a small part is seen and I could not swear it was the moon anyway being an amature.

Meteors and comets are related to each other in this way. They are supposed to be a large piece of nebule brought together by gravity or contract or a piece of something thrown off of a heavenly body and hurled into space. They both produce tails on account of the friction of the air evaporating them forming a luminous vapor.

Visible under the microscope also are Mars' two satellites Phobos and Deimos.

Mars is said to reprogate when as seen from the earth it appears to go in the opposite direction.

Algol one of the brightest stars is really a double star and the illuminosity transfers itself from one star to another, and thus Algol has a minimum.

The moon is in Perigee when it is nearest the earth, as it moves in an eclips around the earth.

It is greater near the the equinoxes than at the solsters.

Comets and meteors it is believed are related to each other because of their general behaviour, but principally because there is no great reason for their not being related.

It may be well, however, to remark that the above must not be taken as fair samples of the answers returned. If such were the case, they would be a discredit both to student and instructor. As a matter of fact the percentages obtained generally were very satisfactory ; but amongst almost two hundred we need not be surprised to find some peculiarities.

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## AN EXCELLENT PRIMER OF ASTROPHYSICS

I have recently been reading a small book entitled "The Spectroscope and Its Work," and feel that I would do a favor to the readers of the JOURNAL by calling attention to it.

The author is H. F. Newall, Professor of Astrophysics in the Cambridge University, England, who is well and favorably known in astronomical circles. The book contains only 163 pages, together with several plates, and it is one of a series of "Manuals of Elementary Science" published by the Society for Promoting Christian Knowledge. Maxwell's "Matter and Motion," published in 1876, is another famous little book in this same series.

After a chapter on the nature of light and an account of Newton's historic analysis of a beam of sunlight, follows a lucid

description of the spectroscope and the varieties of spectra to be obtained. Along with this is an explanation of the chemistry of the sun and stars, and then follows an account of the various other astrophysical applications.

One does not have to read many pages to become assured that the author is thoroughly conversant with the history of his subject, that he is an accomplished investigator and capable of appreciating the work of others, and that he can express his views in clear and simple English.

Any one wishing to obtain a simple yet comprehensive view of the field of astrophysics cannot do better than read this book. Indeed, it is hard to see how the subject could be presented in a more satisfactory way.

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## "DUTCH CHEESE"

Dr. A. van Maanen, a graduate of the University of Groningen, in Holland, was in Toronto on May 5, and the Editor had the pleasure of spending that day in his company. Dr. van Maanen has for the last year acted as a volunteer assistant at the Yerkes Observatory, to which place he went at the suggestion of Professor Kapteyn, the well-known director of the Astronomical Laboratory at Groningen. He will return to America later this summer in company with Professor Kapteyn, and after spending some time at the Mount Wilson Solar Observatory in California, will in the autumn become assistant at the Allegheny Observatory.

Dr. van Maanen relates an amusing incident. It is reported, he said, that Professor Kapteyn was one day at the hospitable table of a well-known American astronomer, and one of the party present asked the visitor if there was anything on the table which he did not recognise. After scrutinising everything for a short time he finally said: "I recognise everything except that" (pointing it out).

There was an outburst of laughter. It was Dutch Cheese!

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## SCIENTIFIC WORK AT VICTORIA, B.C.

The Editor was pleased to learn that the Dominion Government has granted the sum of $2000 for special seismological instruments to be installed in connection with the Meteorological Service at Vancouver. Mr. F. Napier Denison, one of the officers of the Service there, has for a number of years studied earthquake effects in that part of the country, and this new apparatus should assist him in his investigations.

The Editor also learns that Mr. Denison recently gave a lecture on "Astronomy" to a crowded house, in aid of the widows and orphans of the crew of the lost *Titanic*, and the amount of $93 was thereby added to the fund.

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## A PLEASING OBSERVATION

Under date April 21, Mr. T. H. Wingham, Secretary of the Centre of the Society at Hamilton, writes of an interesting observation made with a three-inch telescope, as follows :—

"While writing I would like to mention what to me was a very beautiful sight. Last night, looking at the new moon, the earth shine being quite bright, I saw a small star, I judge about 8th or 9th magnitude, situated almost exactly at the pole, and so near that it could almost be taken for the light on a mountain peak at the end of the cusp. That it was not the latter I was convinced after using a higher power."

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## DEATH OF AN EARLY MEMBER OF THE SOCIETY

Mr. Robert Ridgway, who died on April 25, was one of the earliest members of the society which developed into the Royal Astronomical Society of Canada. He was born at Hollingsworth, England, in 1843. On coming to Canada he first lived in Port Dover, but afterwards taught in Simcoe, Paris and Hamilton. Later he became an official of the Customs in Toronto, from which he retired after serving twenty-five years.

C. A. C.